KNOWLEDGE
AN ILLUSTRATED
MAGAZINE OF SCIENCE
SIMPLY WORDED—EXACTLY DESCRIBED

LONDON: JULY 1, 1891.

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NOTICE.

"KNOWLEDGE" is now published from its own office, 326, High Holborn, W.C. (*near to the end of Chancery Lane*). Cheques and Postal Orders should be made payable to Messrs. WITHERBY & Co., at the above address, to whom all communications with respect to advertisements, subscriptions, and other business matters should be addressed.

GNATS, MIDGES AND MOSQUITOS.—I.

By E. A. BUTLER.

UNDER these names are included a variety of small, delicately constructed flies, the very types, in the insect world, of slenderness, grace, and fragility. But fairy-like elegance of form is no guarantee of gentleness of disposition, and it is united, in the case of *some* of these insects, with a persistence and hardihood in attack, and a bloodthirstiness of nature, that make them some of the most intolerable of pests. In this country, it is true, we are now, for reasons which will appear later on, tolerably free from annoyance on their part; but as they are world-wide in distribution, ranging from the tropics to the Arctic zone, there are many less-favoured lands, in which they still exist in countless myriads, and in which their extermination would be hailed, whether justifiably or not, as an unmixed blessing. They form a sub-section of the enormously extensive order of Diptera, or two-winged flies, an order which is probably responsible for the infliction of a larger amount of suffering and annoyance upon human beings and other vertebrate animals than can be charged upon any other. At least two very distinct types of Diptera may be recognised; on the one hand, there are stout-bodied and comparatively short-legged flies, with minute and curiously shaped antennæ like those of the blow-fly, and on the other, slender-bodied exceedingly long-legged flies, with antennæ of ordinary size and of less extraordinary shape. To the former division (*Brachycera*=short-horns) are referred the house-flies and allied insects discussed on a former occasion in our papers on "House-flies and Bluebottles," as well as hosts of others less familiar; while to the latter (*Nemocera*=thread-horns) belong a weak-limbed and fragile group, the daddy-long-legs or crane-flies, together with the numerous kinds of gnats, mosquitos, midges, merry-dancers, &c. (though not the equally, or even still more, fragile May-flies or day-flies). It is with the section Nemocera, therefore, viz. the "thread-horned" flies, that we are now concerned.

There is amongst the members of this group a striking variety, both as to habits and life-history. Some, in their early stages, lead an active life in the water; others, of a more sluggish temperament, inhabit fungi or rotten wood; others, again, like the notorious Hessian fly, are parasitic on plants, producing gall-like excrescences within which they reside; while yet others, like the daddy-long-legs, whose larvæ are the detested "leather-jackets" of the gardener, live underground, devouring roots of plants as well as vegetable refuse. It might be expected that, with such diversity of habits, there would be correspondingly great differences of form in the adult insects. Such, however, can scarcely be said to be the case, and thus many that are superficially similar in the adult condition may have passed through their preliminary stages under totally different circumstances. This fact, coupled with the fragile and easily damaged structure, and consequent difficulty of preservation, the obscure colours, and the comparatively unmarked characters of the perfect insects, makes the nice discrimination of species a very difficult task, and it is not surprising that the popular judgment has declined this task, and has seen in all these different creatures but varieties for which three or four names at the outside will suffice. Our first business, therefore, must be, as is usually the case in dealing with insects under their popular names, to define our terms, and to say what insects we include and what we exclude, and in what sense we use the terms "gnats, midges, and mosquitos."

Without in the least attempting accurately to distinguish species, it may suffice to say that, when we speak of gnats and mosquitos as household pests, we do not by any means refer to all gnat-like creatures, nor even to all which would commonly be called gnats, but only to such as belong to one particular family, the *Culicidæ*, and which, by their blood-sucking propensities, trouble mankind indoors, either in this country or elsewhere. Nor shall we draw any definite line of distinction between gnats and mosquitos. It is often imagined that mosquitos are creatures confined to warm climates and having nothing to represent them in this country; but the fact is that the difference between a gnat and a mosquito is little more than one of name. To an entomologist they are practically the same thing; both are members of the same genus, *Culex*, and the difference

is, at the outside, not more than that between closely allied species. It is true that the virulence of the "bite" of these creatures in tropical countries is much greater than it is here; and, when one remembers the frightful effects that are sometimes produced on the human body by these little pests, and the strenuous efforts that are made, and the elaborate precautions that are taken, whether in the way of oily unguents, of curtains and nets, or even of burying the body in the sand, to guard against their attacks, it is no doubt disappointing to discover that after all there is nothing so very remarkable in the creatures, and that they can hardly be distinguished from insects with which we are familiar at home. Nevertheless, it is a fact, which we must constantly bear in mind, that the insects to which these names are applied are to all intents and purposes identical both in structure and in life-history, and we are therefore justified in making no distinction here. Moreover, there is no doubt that, even in the matter of virulence, our own gnats vary a good deal, both according to season and to the temperament and sensitiveness of the person attacked. We must not, however, fail to note that there are other flies, belonging to different families, that are also blood-suckers, and in some cases are almost as troublesome as the true gnats and mosquitos. This is specially the case with the small flies called *Simulia*, which are closely allied to the family *Culicida*, and are, it would appear, sometimes called mosquitos in America. Such insects, however, are not referred to here, and what we have to say about "gnats and mosquitos" concerns only the family *Culicidæ*, and, in fact, the genus *Culex*.

Of the term "midges" it is somewhat more difficult to fix the application; it is indiscriminately used of at least two types of flies, quite distinct from one another, one, in most respects except persecuting powers, similar to the gnats and mosquitos, the other very different in appearance, and at first sight more like tiny moths than flies; but it appears also to be popularly used in a loose manner for small and annoying insects of whatever kind, without any definite conception as to the actual form intended. It is obvious, therefore, that when the entomologist hears people talking vaguely of gnats and midges, it is not always easy to understand exactly what insects are being referred to.

With these preliminary precautions, and bearing in mind that not every small, long-legged, fragile fly is a gnat in the sense in which the word is here used—*i.e.*, a blood-sucking gnat—we may now proceed to consider first what sort of being a blood-sucking *gnat* or *mosquito* really is, referring afterwards to those which seem to be more correctly called *midges*. The photographs on the accompanying page will give a pretty good idea of the general form of a gnat. A small head, a considerable portion of which is occupied by the compound eyes, is attached by means of a short neck to a huge globular thorax, so disproportionately large as to give the insect, when viewed sideways, a hump-backed appearance. Behind this the trunk is completed by a long, slender, cylindrical abdomen. A long, straight, beak-like appendage, carrying the mouth organs, points forward from the head, and a pair of more or less tufted, thread-like antennæ form an excellent head-gear, counterbalancing this above. From the upper part of the thorax spreads at each side a single membranous wing, exquisitely delicate, and gracefully fringed along its hinder edge; the place of the customary second pair is taken by the "poisers," long knobbed stalks, as already described in the other division of flies, but proportionately much larger than in those. From the under surface of the thorax start the three pairs of inordinately long legs, upon which, when at rest, the body is, as it were, slung up off the ground, as if on springs. Though the legs consist only of the ordinary parts, yet the divisions seem at first sight to be more numerous than usual, by reason of the great proportionate length of some of the parts, and particularly of the tarsi, or feet, which in the hind pair constitute more than half the entire length of the leg, the leg itself becoming nearly three times as long as the abdomen. The insect is beautified by the addition, on various parts of the body, of minute iridescent scales (Fig. 1), similar to those of butterflies and moths; rows of them adorn the wings, especially along the nervures.

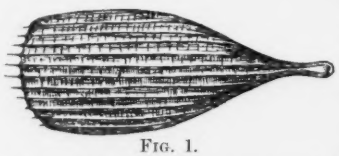

Fig. 1.

A marked difference appears between the sexes. The male can be distinguished by the extraordinary development of the antennæ, which, as frequently in insects of that sex, are, if one may judge from their structure, far more delicate organs of sense than those of his mate. The antennæ of the female consist of a string of cylindrical joints like long beads, each provided with a circlet of fine hairs of no very great length. Those of the male, however, while similarly constructed, have the brushes much longer and more thickly set, especially at the base, for the extreme tip is almost bare. In the photograph the hairs of the female are indistinct through their extreme tenuity, and the charming symmetry of form and arrangement which those of the male naturally exhibit is unfortunately destroyed because the insects have been preserved in balsam, and it is impossible then to ensure that appendages so delicate should be spread out with all the hairs in proper position; no conception, therefore, of their great beauty can be formed from a specimen so preserved.

The greatest interest, of course, attaches to the proboscis, for herein are contained the weapons of attack. In this, again, the sexes differ greatly, and it is against the female only that the charge of blood-sucking can be substantiated. The male is an inoffensive creature, and usually remains in his native haunts, not invading our apartments; for it must be remembered that these flies, like those treated of before, pass their early stages out of doors and enter our houses only when fully grown. The straight, cylindrical spike projecting from the head, though itself no thicker than a hair, is a tube, or rather trough, terminated by two small fleshy lips, the dwarfed representatives of the two large folding leaves which terminate the proboscis of the blow-fly. This tube represents the labium of the normal insect's mouth, and concealed within it lie the much finer *piercing* organs; for the so-called "bite," like that of the bed-bug, consists really of a boring and sucking operation. Along by the upper slit of the trough lies a long bristle-shaped organ, which represents the labrum, or upper lip, and of course all the rest of the mouth organs, except the palpi, lie between this and the labium, *i.e.*, in the trough of the latter. The mandibles and maxillæ, which in insects that feed on solid food are efficient biting weapons, are here, as in the bed-bug, replaced by four fine-pointed, needle-like bristles, the maxillæ being further barbed at the tip like a savage's spear, and the mandibles slightly broadened into a lancet-shaped tip. Besides these, another piercing bristle is found, which is an appendage of the labium itself. Thus there are no less than six boring organs, all contained within a sheath which is itself almost of hairlike fineness. The sheath itself, like so many other parts of the body, is beautifully ornamented outside with abundance of battledore-shaped scales. At its base are two short jointed

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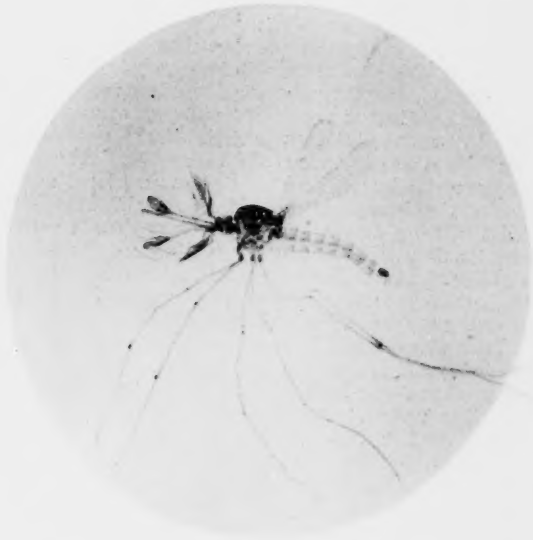
FEMALE GNAT OR MOSQUITO, magnified about five diameters.

The rod-like projection from the head is the labium, from which one of the stylets, probably the labrum, is separated beneath; the other piercing organs lie within it. The minute maxillary palpi can be seen at the base of the labium as two little dark streaks, one above, the other below. The nervures of the wings look thick and cloudy because of the scales that lie along them. This insect "bites," i.e., sucks blood.

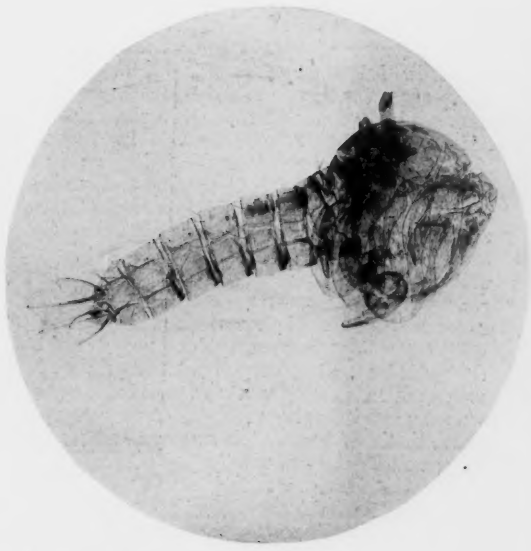


MALE GNAT, magnified about five diameters.

The rod-like labium is seen as in the female, but the maxillary palpi are enormously elongated, and are broadened and fringed at the tip like two clubs, above and below the labium. The antennæ are deeply fringed. This insect does not "bite."

LARVA OF GNAT, magnified about ten diameters.

The broad head and thorax are followed by the cylindrical body, in which the dark digestive tube is seen. At the lower end (tail) a branch projects at an angle, carrying within it the main trachea or breathing tube, the entrance to which is at the extreme tip on the left.



PUPA OF GNAT, magnified about ten diameters.

The tail is furnished with two transparent steering and swimming paddles, and from the back of the thorax arise, as two horns, the two openings to the breathing apparatus (thoracic spiracles). Legs and wings can be seen folded up under the thin transparent skin of the thorax.

MALE AND FEMALE GNAT OR MOSQUITO, with Larva and Pupa, from photographs lent by Newton & Co., of Fleet Street.

Direct Photo Eng. Co., Limited, 9, Barnsbury Park, N.

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organs, the maxillary palpi, representatives of the two unjointed red clubs which are such conspicuous appendages of the mouth of the blow-fly. This straight, unjointed spike is, at first sight, as different as could well be imagined from the elbowed, broad-tipped apparatus with which the house-fly and the blow-fly sip their liquid nutriment; yet both are but extreme modifications of the same plan, the rasping and sucking elements being carried to the summit of perfection in the one case, and the boring or piercing ones in the other. Many intermediate forms may be seen, as in the drone-flies, breeze-flies, wasp-flies, and others which have no popular names, and a very interesting series showing the gradations might without much difficulty be prepared.

Now how is this collection of weapons used? The little insect drops gently and daintily down on to the spot it has selected for its attack, and the descent of so light and airy a being is likely to leave the victim unconscious of its presence, unless he has actually seen it settle. Then the proboscis is pointed downwards, and the tiny lips that form its tip pressed against the flesh. The bristles within the gutter-like sheath, being then pressed together into one solid boring implement, their common tip is forced down on the flesh, and as they enter the wound, the trough in which they were lying separates from them in the middle, and becomes bent towards the insect's breast, the two little lips all the while holding on tight. The greater part of the length of the stilettos is then plunged into the victim's flesh, and the blood is drawn up the fine interstices of the composite borer. The wound, though six instruments are concerned in making it, is extremely minute.

So far, our description has concerned the proboscis of the *female* gnat or mosquito only. That of the male is somewhat different. There is still the straight stick-like labium, but the palpi are greatly elongated, running along by the sides of the tubular proboscis as far as, or even beyond, its tip, and tufted at the end. A fine rod-like organ may be separated from the labium, but whatever else the insect may have in this way, it does not use for sucking blood, being in fact perfectly harmless.

In their earlier life these insects inhabit ponds and stagnant water generally. The larva and pupa are shown in the accompanying photograph. The former, an odd-looking, big-headed, wriggling creature, swims about head downwards, devouring all sorts of organic refuse in the water, coming to the surface to breathe through the opening at the end of the tail-branch. The pupa also swims about, but with its head upwards, and though active, it takes no food. It requires to come to the surface occasionally for air, which is taken in at the two little projecting horns on the thorax. Fuller details of these early stages and of the entire life-history must be reserved for our next paper.

(*To be continued.*)

ON THE PLAN OF THE SIDEREAL SYSTEM.

By J. R. SUTTON,* B.A., Cantab.

MANY lines of circumstantial evidence go to show that the Milky Way is a ring-shaped formation, roughly circular in section, one of the most important depending upon the almost obvious connection between the lucid stars lying on or near the galactic belt and the nebulous looking matter of which it consists. It scarcely needs demonstration that all these lucid stars are not necessarily *galactic* (under which term we include all stars actually within the stream, or which, though outside it, are so near as to influence it to an appreciable extent), nor is it likely that the relation when it does exist will always be made out. Nevertheless, in many, perhaps the majority of cases, so far as the (optically) extra-galactic stars are concerned, the problem is not a difficult one for any person on whom the shadow of John Michell's mantle has fallen. Whenever, for example, a star or group of stars lies opposite or inside a gap in the profile of the Milky Way; or whereve. any of its numerous branching lateral offsets terminate in the immediate vicinity of a bright star or star-group, we are entitled to assume, if the doctrine of chance has any credit at all, that these stars are intimately associated with, if they are not the agents which have determined the conformation of the stream, and they may therefore be considered a part of it.

When we come to deal with the stars optically upon the stream the problem is not quite so simple. Such stars may be either within the stream or without it, and, if the latter, may or may not be galactic. We know that the parts of the sky traversed by the Milky Way contain very many more bright stars than would be the case if the stars were uniformly distributed over the whole celestial sphere; and Probability interprets this to mean that the chances are enormously against a general dissociation between the two. This, however, is not exactly the same as *proving* a relationship. If it were, it would mean that all, or nearly all, the stars so situated are galactic. On the contrary, although the statement may be true in general, it is not possible to indicate at random any star or star-group as therefore forming part of the Milky Way.

Such details have to be decided independently, from particular and not from general considerations. The only instances we can be tolerably sure of are those (1) in which a stream of lucid stars and a nebulous streamer branch out together from the main course of the Galaxy, and turn to the right or left up to the apex of either without parting company; (2) in which a star or star-group lies in the midst of a small dark space surrounded by fields of normal brightness; and (3) in which stars are seen significantly mixed up with clustering aggregations of nebulous matter. In all cases of this nature there is no reason to doubt that the Galaxy and the lucid stars are mutually dependent.

There is no necessity just now to discuss these points at any greater length; that has been done elsewhere. They have been introduced, in brief, simply to indicate the principal lines of evidence made use of in the attempt to prove the ring-form of the Milky Way, and to avoid continual repetition in the course of this discussion.

It is clear that some of the clusters in the Milky Way might be streams of stars seen in projection.

Suppose an observer to select some star-group lying at the extremity of a straight galactic streamer, and then to take up such a position in space that his line of sight should pass through the group and along the axis of the streamer. If the streamer be supposed divided into sectional laminæ of the same thickness, these, taken singly, would be of the same intrinsic brightness however far off they might be; and in the case of a cylindrical stream their apparent size would vary inversely as the square of their distance from the observer. Hence the streamer would have, from the assigned position in space, the characteristics of a close globular cluster, its brilliancy decreasing gradually but rapidly towards its edges. Moreover, the lucid star-group at its apex would be pro-

* Mr. SUTTON is at present in South Africa. His paper was forwarded from Kimberley with a letter in which he apologizes for writing on such a subject in the absence of books of reference. His ideas with regard to the association of the belt of great stars with the Milky Way were formed entirely independently and before he had seen my paper in the May number.—A.C.R.

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jected into it, and so help to increase the impression of its being globular. The obvious inference is that we are unable to decide off-hand whether any single cluster is really a cluster or a drift of stars.

But such a theory with regard to the many clusters lying on the Milky Way would involve the existence of many straight streamers radiating towards our sun. If the Milky Way is a ring, and the sun occupies a central position, this might be possible, and the theory is supported to some slight extent by the behaviour of those apparent clusterings in the field of the Milky Way, whose brightness increases not towards their centres but from one side to the other, the magnitudes of the larger stars upon them following the same order. This is exactly what should happen in the case of a spicular projection *slightly* inclined to the line of sight. Other instances having the same tendency will readily occur to the student. But if any of the apparent clusterings are streaming appendages seen in perspective, we are met at the outset by the difficulty that none of them are so bright as we should expect; reasoning merely from first principles, their brightness is evidence enough that their length (if length they have) is small in comparison with the great arm stretching from Cygnus to Ophiuchus. The nebulous clouds in Aquila would certainly be darkness itself contrasted with the condensed brilliancy which would be exhibited by the spur in Scorpio to an observer situated on its produced major axis. Indeed the conspicuous cluster in the sword handle of Perseus offers the only possible comparable example, and not altogether a good one either.

It is necessary, then, to give up the assumption that any great galactic drifts lie within the space enclosed by the Milky Way, and pointing towards us. This may tend to shake our faith in a ring-form theory of the Milky Way—indeed in any of the present theories of its structure based on its streamy nature, such as Proctor's spiral theory; furthermore, according to the same reasoning, it seems probable that the great branch reaching to Ophiuchus, and the meanderings in Scorpio, are what they give the impression of being, namely, at approximately the same distance from us, and therefore parallel to the main course through Aquila and Sagittarius. We shall, however, have presently to consider this matter in another light when speaking on the probable position in space of the great appendages in Perseus and Cepheus. And incidentally we shall have reason to point out that the Milky Way is by no means obviously a stream of stars *of all sizes*.

Any theory which could account for the extraordinary evenness of outline of the Milky Way would have much in its favour, and this a ring theory has, as well as the spiral stream theory.

It is curious that the assertiveness of the Milky Way among the stars has always been tacitly recognized as a sign of its importance. Thomas Wright thought that its brilliancy represented the greater depth of the universe in its plane; and the two Herschels followed suit with different degrees of scepticism notwithstanding John Michell and his mathematical formulæ. Proctor thought that the Milky Way was a stream of stars of all sizes, all those scattered over the rest of the sky being in a sense sporadic, and not of any particular moment in modifying what he thought to be the architecture of the universe; and it must be admitted that his reproduction in one photograph of Argelander's forty charts might well seem to be very substantial grounds for the idea.

But although it is true that the Milky Way is richer in lucid stars than any area of equal size outside it, it is not true that it is the richest *great-circular belt* of the sky. That distinction is claimed by a belt arranged about a great circle through Cygnus, Perseus, Taurus, Orion, Crux, and Scorpio. Besides, the stars lying within it offer the clearest example of a star-stream it is possible to conceive. That it is a real star-stream is suggested first of all by its undeviating direction. A person standing under Orion will have overhead a most imposing arch of stars, springing with perfect symmetry from the horizon on either hand in Crux and Perseus without anything that can be called a break. Moreover, it passes across an exceedingly dark part of the sky. Below the horizon on the one hand it can be distinctly traced as far as ε and ζ Ophiuchi, where it seems to end, on the border of an empty space, sending out, meanwhile, a small arm from Crux, along the main course of the Milky Way as far as υ Sagittarii. In the same way, and as easily, we can trace the other continuation of the arch through Perseus, Cassiopeia, Cepheus, Cygnus, and Lyra almost or quite to α Ophiuchi on the other side of the empty space mentioned above. This end also sends out an arm in the direction of Aquila apparently as a feeler for the star. In one respect the great star-belt offers a curious analogy to the Milky Way: both are cut completely across, one in Ophiuchus, the other in Argo; and both spread out fanwise on either side of the respective gaps, and to complete the resemblance, just as the nebulous magellanic clouds lie off, though having no defined connection with the gap in Argo, so do the apparently free star-groups of Ursa Major and Hercules lie off the gap in Ophiuchus.

Still these facts only suggest, and do nothing to prove, that the great star-belt actually marks the course of a real ring of stars in space. But there is a class of facts, well worth examination, which seems to place the matter beyond doubt.

First, then, if we trace the course of the Milky Way from Auriga through Monoceros we shall find it the most tame and unexciting object imaginable. It is as monotonous as an unvarying brightness can make it. With the solitary exception of β Tauri, no star of any magnitude occurs until we come to Argo, in which constellation the Milky Way and the great star-belt intersect at a very acute angle, so that the two are practically in company for a considerable space. Here there is a sudden metamorphosis: from being regular and unbroken the former becomes torn up into indescribable confusion—torn into ribbons so to speak, and it is pretty clear that the stars are the agents effecting the disruption, as we have shown elsewhere. For here we get all the associations referred to in the first two paragraphs of this article. Parting company with the stars (in Sagittarius) the Galaxy resumes very nearly its even outline and untroubled aspect until it intersects the star-belt again in Cygnus. Here the same phenomena of disruption recur.

Furthermore, there is not a galactic off-set of any size worth mention, whose shape, direction, and aspect are not determined by the stars in the great star-belt. The streamer in Perseus lies directly along, and that in Cepheus, across it. Those in Ophiuchus and Scorpio bend equally towards it. Indeed, the Milky Way itself, between Canis Major and Sagittarius, seems to have a decided double-warp of the same nature: curving round from either constellation perchance to come sooner into the plane of the star-belt. The spreading finger-shaped projections, facing each other across the gap in Argo, illustrate very forcibly the predominance of the latter in this respect.

Lastly, the area covered by the Milky Way is rich in lucid stars, because it crosses the richest parts of the star-belt. The conclusion seems to be emphatically forced

upon us that the great-star-belt is a genuine girdle of stars in space; in which, also, the foundations of the sidereal system are laid, the Milky Way being an appendant to it, of lesser rank. In short, the most noteworthy arrangement in the architecture of our universe seems to consist of a great ring of large stars intersecting an equal ring of small ones at the extremities of a common diameter. Let us recapitulate the evidence: To start with, we have the probability—shall we say certainty?—that the Galaxy is a ring-shaped structure, having, as we sought to show, no great branches in its own plane. Next, we have the significance of an almost entirely isolated, symmetrical belt of bright stars (stars singularly uniform in magnitude and distribution) encircling the whole heavens, and cutting the Milky Way in two exactly opposite parts. Then we have the striking suggestiveness of the disturbed state of the Milky Way in these parts, coupled with its evenness both in outline and aspect elsewhere. Lastly, we have the evidence derived from the affinity between the Milky Way and the stars in the belt; the galactic off-set in Perseus lying along the direction of the belt, the stellar off-sets from Cygnus to Aquila, and from Crux to Sagittarius, lying along the Milky Way; the galactic streamers, moreover, in Ophiuchus and Scorpio, nay, even the main stream of the Milky Way, turning aside to the star-belt just where the greatest angular distance separates them.

The double-ring structure enunciated above dovetails in with all these points; indeed, it seems the only logical deduction from them. Both Sir William Herschel's hypothesis of an even distribution of stars throughout our stellar system, and Proctor's spiral theory, fail utterly to account for the fact of a zone of bright stars associated with, but differentiated from, a zone of small ones in the manner observed. Further than this, the theory of a double-ring furnishes us with a rational explanation of the conspicuous absence of streamers round the interior face of the Galaxy, for it tells us where a powerful extraneous force is to be found counteracting altogether the action of the Milky Way upon itself.

THE EXPERIMENTAL METHOD IN GEOLOGY

By VAUGHAN CORNISH, B.Sc., F.C.S.

THE record of the investigation of a geological problem may generally be divided into two parts, the descriptive and the explanatory. A rock, for instance, is described according to its mode of occurrence, structure and mineralogical composition; then follow deductions as to the epoch at which it was formed, and the mechanism of the actions by which its particular characters have been produced. This, as a rule, marks the limit of the geologist's investigation of such a problem; seldom, far too seldom, are the conclusions submitted to the decisive test of experimental methods. This lack of the confirmatory evidence of experiment makes a large part of the literature of Geology very unsatisfactory reading, the deductions being too often either indefinite or inconclusive. In the present article we give a sketch of some of the efforts which have been made to raise Geology to the rank of an experimental science.

In the last years of the eighteenth century a controversy raged between the schools of Hutton and of Werner as to whether heat or the action of water had been the dominating influence at work in the formation of the rocks of the earth's crust. By what agency, for example, had chalk been converted into limestone or marble? How can this have been effected by heat, said the school of Werner, since heat decomposes carbonate of lime, expelling the carbonic acid? The answer to this question was furnished by the experiments of Sir James Hall, "*On the action of heat as modified by pressure.*" Chalk was heated in a gun-barrel, the end of which was firmly closed. Under these conditions, the pressure increasing as the temperature is raised, the carbonic acid is not driven off from the carbonate of lime, the change induced being not chemical but physical, the powdery non-coherent chalk being converted into a compact crystalline mass, having all the characters of limestone, or of marble. Hall also investigated another problem connected with the same controversy. Hutton maintained the purely igneous origin of those rocks which have characters similar to the modern lavas. It had, however, been noticed that if a piece of a crystalline rock were melted in a crucible it was not reproduced on cooling, but that an uniform glassy mass was formed. By a judicious combination of the methods of observation and of experiment, Hall obtained important evidence as to the conditions of crystallisation of rocks. He observed during eruptions of lava that a great part of the crystallisation of the constituent minerals took place slowly, and by degrees, during the gradual cooling of the mass of molten rock. Basing a method on this observation, he melted various rocks in graphite crucibles, and maintained the materials in a state of fusion for a long time, taking care that the temperature should be somewhat above that necessary to melt the glassy mass. Crystals gradually formed, and a crystalline rock was reproduced, of which the melting point was higher than that of the glass formed in previous experiments, where the cooling had been rapid. Similar experiments were conducted about the same time (1804) by Gregory Watt. They were on a larger scale, a reverberatory furnace being employed in place of a crucible. The molten material was only allowed to cool with extreme slowness. From time to time samples were withdrawn and examined after solidification. Those in which the annealing process had continued longest were the most perfectly crystalline, and possessed the highest specific gravity, just as a natural crystalline rock, such as granite, is denser than a glassy rock (*e.g.* obsidian) of the same chemical composition. These early experiments elucidated several important points with regard to the processes which have taken place in the formation of the eruptive rocks. The products obtained were, however, at most very imperfect reproductions of the natural rocks, and the methods for the determination of mineral species were at that time too rough to allow of the identification of the small and imperfect crystals obtained. Before the date (1866) of the next important experimental research on the formation of rocks by igneous fusion, the application of the microscope in petrological work had effected a revolution in this respect. A slice of rock, so thin as to be transparent, reveals to the microscope the outline, and even the internal structure, of the minute crystals which form its groundwork or *base*. The crystal of each mineral species shows its characteristics of form, the particular angles at which its faces are inclined to one another, and the lines developed in the process of grinding the thin section which indicate the directions of cleavage. Not less important in identification are the optical characters which determine the tints which different parts of the field of view assume according as the polarised light passes through the plate of one or other of the minerals of which the rock is composed. The refinements of optical analysis enable the identification of the species to be made with certainty even in crystals of microscopic size. At the date to which we have referred, M. Daubrée published his experi-

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ments on the reproduction of the rocks of a certain class of meteorites. The meteorites being melted and kept for some time in the liquid condition, the constituent minerals began to crystallise out, and finally, after slow cooling, a rock was produced having the same constituent minerals as the original meteorite. Almost the only difference between the meteorites and the artificial products was the absence in the latter of that *brecciated* structure which frequently characterises an eruptive rock which has undergone violent mechanical strains. By the employment of the modern refinements of microscopic and of chemical analysis, Daubrée was able to establish the absolute identity of the minerals contained in his artificial products with those of the meteorites. The class of meteorites for which the method of reproduction was found successful were those containing the smallest proportion of combined silica, characterised by the presence of olivine and augite and by the absence of the feldspars. Except for the presence of metallic iron, the mineral composition of these meteorites is very similar to that of what are termed the ultra-basic rocks, *i.e.*, those the analysis of which shows the smallest proportion of silica. Many basalts and other lavas come under the category of ultra-basic or basic rocks. Observational evidence appeared, however, to favour the view that these rocks had not been produced by the purely igneous method employed by Daubrée, but that the action of water had played an important part in their formation.

It was in 1878 that MM. Fouqué and Lévy commenced the celebrated research in which they showed that the more basic eruptive rocks can be reproduced in every detail of mineral composition and structure by the action of heat alone without invoking the aid of pressure, or the intervention of water or any other substance not forming a constituent of the rock. To appreciate the details of their method it is necessary to make clear the guiding data which were furnished by the study of the minute structure of rocks. Some eruptive rocks are entirely composed of an aggregate of perfectly crystallised minerals. One or more of the constituents (in granite, the quartz) may not show crystalline faces; they have presumably solidified last and have been compelled to mould themselves round the crystals already formed, but their structure is completely crystalline, as is shown by their action on polarised light. Other rocks differ from the *holocrystalline* in that the crystallised minerals are imbedded in a vitreous or glassy matrix which scarcely affects polarised light. These rocks are classed, from the character of the ground mass, as glassy rocks. The most common structure of eruptive rocks is that of the third class, of which the ground mass has begun to crystallise before solidification, but the crystallisation has only gone as far as the production of *microliths*. These are crystals of small size, most frequently microscopic, which are so far developed that the determination of their species is readily effected. They are seen to be grouped round the larger crystals of the rock in a manner plainly indicating their later formation. It appears reasonable to suppose that the microliths are formed during and after the welling up of the rock, whilst the formation of the large crystals may be referred to a previous epoch before the disturbance of the fluid mass from its subterranean position, when a condition of calm fusion favoured their growth and development. The temperature at which they were produced must be supposed to be higher than in the case of the microliths. Between these two epochs of crystallisation comes the eruption, during which the older crystals may be rounded, worn, or broken by shock. Hall had shown that to obtain a crystalline structure instead of a glassy mass, it was necessary to keep the material at a temperature slightly above that of the melting point of the glass; but if, as appeared probable, the minerals of the different epochs of crystallisation did not possess the same degree of fusibility, it would be necessary in order to reproduce this association of minerals to maintain the materials at a series of temperatures successively decreasing. The result of the final operation might be expected to be the solidification of a mass of microliths of the more fusible minerals cementing together the larger crystals already formed. Such was the method employed by Fouqué and Lévy, and the result was in complete accordance with their expectations. As an example of their work, we will describe the reproduction of a basalt precisely similar in character to certain basalts found in the Department of Auvergne. A mixture of substances prepared in the laboratory of the same chemical composition as the rock was placed in a platinum crucible, which was maintained at a white heat for forty-eight hours. A sample taken out at the end of this time, and allowed to cool rapidly, showed on solidifying crystals of olivine imbedded in a brown coloured glassy matrix. At the end of the first forty-eight hours the position of the crucible in the furnace was changed so that the temperature was lowered to that corresponding to a bright red heat, at which it was kept for a second period of forty-eight hours. The product obtained at the end of this time showed the crystals of olivine as before, but imbedded not in a glass but in a matrix composed of microliths of augite and of soda-lime feldspar. Among the other rocks reproduced was a leucite-lava, the crystals of leucite having rounded angles just as in the natural rock, showing that this peculiarity is not necessarily due, as had been supposed, to the effects of disturbance after the first epoch of crystallisation. The rocks produced by the methods we have described are of the same character as those formed in the volcanic eruptions of the present time, which belong to the class of the more basic rocks. The more siliceous rocks, such as granite, which contain free silica in the form of quartz, do not appear to be formed under the conditions obtaining in the eruptive processes which geologists have been able to observe in actual operation. When the materials of the *acid* rocks are subjected to the processes above described, the minerals which crystallise out are not those of the original rock, but are of different crystalline form, even when they have the same chemical composition. The excess of silica remains in the uncombined state, but has characters resembling those of the variety known as tridymite rather than those of quartz. The acid rocks and their characteristic minerals (as quartz potash-feldspar and soda-feldspar) have doubtless been formed by processes radically different from that of simple fusion. The minerals above mentioned have been reproduced by the reaction of suitable materials in the presence of water, at a high temperature and pressure. Hitherto it has not been found possible to produce the compacted association of these minerals which constitutes an acid rock. Sufficient data have, however, been obtained to justify the belief that at no distant date the problem of the mode of formation of this class of rocks will be solved by the experimental method.

One of the most important contributions to experimental geology during recent years, is the discovery of Spring, that pressure is capable of inducing chemical change independently of its effect in raising the temperature of bodies. This discovery has a direct bearing on the phenomena of *metamorphism*, or the bodily conversion of sedimentary rocks into others of a completely different character. Spring has shown, that by the application of great pressure, chemical combination is induced, in cases where the compound occupies a smaller volume than the components, and conversely that a decomposition is brought

about by pressure, when the volume of the bodies formed by decomposition is less than that of the compound. Briefly, pressure brings about such chemical changes as are accompanied by a contraction. The apparatus employed in these experiments consisted of a small steel chamber, in which the substances were placed, furnished with a piston worked by a powerful lever, provided at the end with a heavy weight. If the piston were forced down rapidly the substances would be heated, and it would be impossible to discriminate between the changes due to rise in temperature and those due to increased pressure. In Spring's apparatus the lever is lowered very gradually, its descent being regulated by a finely cut screw. The steel chamber is surrounded by water, in which is placed a delicate thermometer, and the descent of the piston is operated so gradually that there is practically no rise of temperature. These experiments afforded the first example of the direct conversion of mechanical work into chemical energy.

As a last example of the application of experimental methods in Geology, we will deal with some of the problems presented by mineral veins. The cracks and openings by which rocks are traversed are in some cases unfilled, in others they contain *débris* of the rock itself, and lastly, they are sometimes found filled with foreign minerals, and are then known as mineral veins. Most of the fine well-crystallised minerals which adorn museum collections come from mineral veins, or from cavities in rocks, known as "geodes." Tin veins, for instance, contain the oxide of tin, cassiterite, in large well-formed crystals. Others contain oxide of iron, also well crystallised; and another class contain the metallic sulphides, such as galena, the common lead ore found in Derbyshire and elsewhere. The processes by which these minerals have accumulated in the veins, and the mode in which their crystallisation was induced, long remained a mystery. In studying the characters of tin veins, Daubrée was struck by the constant presence of minerals, such as apatite, topaz and tourmaline, which contain the elements chlorine and fluorine. It is known that the chloride and fluoride of tin are volatile, and that these compounds are decomposed by water, the hydrogen of the water forming hydrochloric or hydrofluoric acid gas and the oxygen combining with the metal. Experiment showed that if the vapour of water be brought in contact with that of chloride of tin at a fairly high temperature the oxide of the metal is formed in crystals, having all the characters of the mineral cassiterite. Later, Sainte-Claire Deville showed that by passing hydrochloric acid gas over strongly heated oxide of tin, the chloride of the metal was formed, and steam. These two gases are carried on by the current of hydrochloric acid gas, and in a somewhat cooler part of the apparatus react again upon one another, re-forming hydrochloric acid, and depositing the oxide of tin in the crystalline form. Hydrofluoric acid and other re-agents which have been found to act in a similar manner have been termed *mineralisateurs*. They are capable of effecting the transport of non-volatile substances, such as oxide of tin, depositing them in the crystalline form, and, their work done, they leave no trace of their former presence except in the combination of their more active elements with constituents of the surrounding rock or of certain minerals of the vein, the gauque minerals as they are termed. One of the commonest of the gauque minerals is calcite, and by passing the vapour of chloride of phosphorus over heated calcite, Daubrée found that apatite is formed, a mineral which, as has been said, is characteristic of tin veins. In the formation of the metallic sulphides, sulphuretted hydrogen has played the part of *mineralisateur*. In some cases, no doubt, the mineralising action is effected by the vapour of the active substance ascending from the heated interior; in other cases, as in the neighbourhood of the great Compstock Lode, the substances are in solution, subterranean streams saturated with sulphuretted hydrogen and other powerful solvents serving to extract the metallic compounds from the rocks in which they are present in small quantities and concentrating them in the veins. By such processes metallic ores are collected in the rock veins, which thus become the great storehouses of mineral wealth.

FLYING ANIMALS.

By R. LYDEKKER, B.A.Cantab.

(*Continued from page* 115.)

THE wing of a Bird, although constructed on the same fundamental plan as that of a Pterodactyle, differs altogether in the manner in which the bones corresponding to those of the human hand have been modified for the purposes of flight. In the wing of a Bird only three fingers are represented at all, and these probably correspond to the thumb, index, and middle fingers of the human hand. Moreover, while the thumb is only represented by a small splint of bone, which carries the so-called "bastard wing," the bones of the index finger are flattened, and much larger than those of the third one, with which, in living birds, they are more or less closely united. This finger, therefore, forms the chief part of the extremity of the wing or pinion; but, instead of its bones being much longer than those of the arm and fore-arm put together, as is the case with the elongated outer finger (4th or 5th, as the case may be) of the Pterodactyle, it is much shorter, and, indeed, is frequently shorter than either the bone of the upper arm or those of the fore-arm alone. The finger, therefore, is the least important part of a Bird's wing, whereas the outer finger is by far the most important element in that of a Pterodactyle.

It would involve a large amount of detail to give a full description of the arrangement of the feathers of a bird's wing; and it must accordingly suffice to say that the large flight-feathers carried by the pinion are known as the *primaries*, while those attached to the larger bone of the fore-arm are termed *secondaries*; the smaller feathers which overlie these being designated as the *wing-coverts*. In all living birds, as we have said, the bones representing the fingers are flattened, and those of the index and third fingers more or less united together. In the *Archæopteryx*, which is the oldest known bird and a contemporary of the Pterodactyles of the Lithographic Limestones of Bohemia, all the three fingers were, however, perfectly separate from one another, and each ended in a claw; while the index was not greatly larger than the other two. We have, therefore, in this bird a decided approach to reptiles; from which class it is considered that birds were originally derived.

In addition to their wings we must not omit to mention that the tails of birds form an important aid in flight, when they act as a kind of rudder. In all living birds the bones of the tail are extremely few in number, and the large tail-feathers all take origin close together, and are generally spread out in a more or less fan-like manner. Our old friend the Archæopteryx had, however, a very long lizard-like tail, with a pair of feathers arising from each of its numerous joints, after the manner of the feathers on an arrow. It will, however, be readily imagined that such a long unwieldy tail was by no means calculated to act as an efficient and compact rudder; and the shortened tails of modern birds appear, therefore, to

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be a decided improvement on the early type. It seems, indeed, that in all groups of Vertebrates capable of true flight a long tail has been found disadvantageous, since among the Pterodactyles the more specialised kinds found in Europe had discarded the long tail of the species represented in Fig. 8; and the same holds good with regard to the large toothless kinds found in the cretaceous rocks of the United States. Again, the most specialised, or insectivorous Bats are remarkable for the shortness of their tails. From the relative shortness of its wings, coupled with the long unwieldy tail, it is probable that the Archæopteryx was but a poor flyer, and was, perhaps, altogether incapable of making the long-sustained flights of our modern birds, though it must undoubtedly have been a true flyer.

Birds vary greatly in the relative proportions of the component bones of the wing, so that among the strongest flyers we find that whereas in the giant Albatross of the tropical seas the bones of both the upper and fore-arm are enormously elongated, in the Swift that of the upper arm is so shortened and thickened as to be scarcely recognisable. The form and arrangement of the flight-feathers are, however, of still greater importance in modifying the shape of the wing, but the reader desirous of information on this subject must consult one of the numerous works on the structure of birds.

Coming now to the highest class of animals, the Mammals, we shall find that while true flight is only possessed by the whole of the members of a single order, spurious flight occurs among certain members of three widely distinct orders; and it is curious to notice the remarkable external similarity between some of these animals possessing the power of spurious flight, while they are structurally so different from one another.

Commencing with spurious flight, the first Mammals we have to mention are the Flying Phalangers of Australia, which belong to the great order of Pouched or Marsupial Mammals, described in a previous number of KNOWLEDGE, and are closely allied to the so-called Opossums of the colonists. There are several genera of these curious and beautiful creatures, distinguished from one another by the character of the skull and the shape of the parachute, which may be either very broad or very narrow. This parachute consists of an expansion of the skin of the sides of the body, extending from the wrist of the fore-leg to the ankle of the hind-leg, with a smaller development between the neck and the front of the fore-leg. The Flying Phalangers are strictly nocturnal in their habits, and are able to take enormous flying leaps from tree to tree, during which they descend in the first part of their course, but acquire a slightly upward direction before they alight.

It is not till we come to the order of Rodents, or those Mammals which, like Hares, Rats, and Beavers, are provided with a pair of chisel-like gnawing-teeth in the front of each jaw, that we again meet with Mammals having the power of spurious flight. Among the most curious of these are the so-called Anomalures of Africa, which are small Rodents nearly related to the Squirrels. Here we find the parachute connecting both pairs of limbs together, as in the Flying Phalangers, but with the additional peculiarity that there is a spike-like rod of cartilage projecting from the elbow, which, by acting in the manner of a yard-arm, allows the width of the expansion to be greater than could otherwise be the case. This rod, together with the presence of a series of scales along the sides of the base of the tail—from which the creatures take their name—serves to distinguish the Anomalures from the Flying Squirrels. Of the latter there are three genera, mostly found in the oriental region, although a few species range into North America and Europe. These creatures exactly resemble ordinary Squirrels in general appearance and habits, with the exception of having a parachute connecting the front with the hind limbs, after the manner of the Flying Phalangers. In some species an additional membrane connects the root of the tail with the thigh, but this is wanting in others. The flight of the Flying Squirrels is precisely like that of the Flying Phalangers; and if the two were to be found together, it would be quite impossible to distinguish the one from the other during flight. Flying Squirrels, however, utter a sharp, squeaking cry during their flight, while the Flying Phalangers appear to be silent. Ordinary Squirrels, as we all know, are capable of taking long leaps from bough to bough, and in the Flying Squirrel it is merely an excess of this power which, owing to the development of the parachute, assumes the character of flight. A precisely similar connection obtains between the ordinary Phalangers and the Flying Phalangers. There are a large number of species of Flying Squirrels, which are mostly of comparatively small size, although one species, from the north-west of Kashmir, is as large as a rabbit. Although their cries may frequently be heard at night in the districts which they inhabit, Flying Squirrels are but seldom seen. Their flight may be extended to a distance of twenty-five or thirty yards.

The Flying Lemurs, of the Malay Peninsula and the Philippines, present a type of Mammal in which the faculty of spurious flight has attained its maximum of development. These animals come nearest, in general structure, to the so-called Insectivorous Mammals, such as the Mole, Shrew, and Hedgehog, and are, therefore, usually regarded as forming an aberrant group of that order. In them not only are the fore and hind limbs of either side connected together by an expansion of the skin of the sides to form a parachute, but the expansion of the skin also extends backwards between the hind legs, which it connects with the long tail completely up to its tip. Moreover, although the fingers and toes are only of the ordinary length, yet they also are connected by a membrane, in the manner of the webbed foot of a duck. At night, during which time they become active, the Flying Lemurs will take flights of upwards of seventy yards in length, and thus far outrival the Flying Squirrels and Phalangers in this respect. Bats, as we shall notice shortly, are known to be closely allied to the Insectivores, and the Flying Lemur seems to show us how an ordinary Insectivore may have become gradually modified into a Bat; for it would only require the elongation of the fingers and a somewhat greater development of the parachute to transform the Flying Lemur into a creature exceedingly like a Bat.

Bats, which are familiar to all of us, are the only Mammals endued with the power of true flight; and although they are evidently related, as shown, among other features, by the structure of their teeth, to the Insectivores, yet they are so different as to be entitled to rank as a separate order by themselves. In being the only truly flying Mammals they hold, as has been well observed, a position in the class precisely analogous to that occupied among the Reptiles by the Pterodactyles. That they have, however, no sort of connection with the latter group is perfectly evident from the structure of the fore-limb, or wing, which we now proceed to explain.

The wing of a Bat is composed of a thin naked membrane supported by a great extension of the bones of the fore-limb; this membrane being continued backwards to connect the hind-legs with the whole length of the tail.

In the fore-limb, of which the skeleton is represented in Fig. 4, the bones of both the arm and fore-arm are

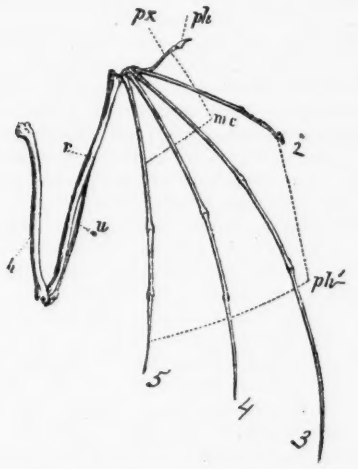

Fig. 3.—The bones of the right fore-limb of a Bat, seen from above. *h.*, bone of arm; *r.u.*, bones of fore-arm; *px.*, thumb; *ph.*, claw of thumb; *m.c.*, metacarpus; ph^1, 2nd, 3rd, 4th, and 5th fingers.

relatively slender and considerably more elongated than usual. The thumb remains comparatively small, and ends in a claw; but all the other fingers—more especially the third or middle one—are enormously elongated, so that the third, fourth, and fifth, which have no claws at the end, are absolutely longer than either the fore-arm or the arm. Between these elongated spider-like fingers the wing-membrane is stretched, the whole structure permitting of the wing being folded, when at rest, in the manner familiar to all. A comparison of Fig. 3 with Fig. 2, or, still better, with the figure of the skeleton of a Pterodactyle, given in the article on Flying Dragons, will show how essentially the wing of a Bat differs from that of a Pterodactyle. As we have said, the single finger supporting the wing-membrane of a Pterodactyle corresponds either with the one marked 4 or that marked 5 in Fig. 4 (probably the latter), and it may therefore be said that while a Pterodactyle flies with one finger, a Bat flies with its whole hand. Equally marked is the difference between the wing of a Bat and that of a Bird; the latter having only the first three fingers of the Bat's wing developed, and all of these being strangely modified from the ordinary form, while the chief elongation has taken place in the bones of the arm and fore-arm, instead of in those of the fingers, and flight is effected by the aid of feathers instead of by a membrane.

This completes our survey of the various modes of flight obtaining in the animal kingdom. In it we have indicated the difference between spurious and true flight, have shown how the former is but an extreme development of the long leaps taken by arboreal animals, and have suggested how it may have gradually passed onwards into true flight. We have also seen how the wings of the Invertebrate animals differ *in toto* from those of the Vertebrates; while among the Vertebrates true flight has been independently developed in three distinct groups—Pterodactyles, Birds, and Bats—on totally different structural lines; the latter instance thus affording us an excellent example of the way in which different groups of animals may be variously modified to occupy the same position in the realm of nature. The supersession of the Pterodactyles by the Birds as the lords of the air is in accordance with what we have observed elsewhere, namely, the replacement, with the advance of time, of a lower by a higher type of organization. The Bats, indeed, which belong to the highest class of animals, appear to have been the latest in which the power of flight has been developed; but since most of them are of comparatively small size, and of more or less completely crepuscular and nocturnal habits, they have never entered seriously into competition with the Birds, so that both groups are found existing side by side in full development.

THE COMPANION TO α URSÆ MAJORIS (β 1077).

By S. W. BURNHAM.

THE close companion to α Ursæ Majoris, which was found with the 36-inch refractor in the early part of 1889, has now been measured each year since that time. These observations show clearly that the companion is moving round the principal star in a retrograde direction, and that the two form a physical system. The proper motion of α is not large (0·144″ in the direction of 240·5°), but it is sufficient to show in the measures of so close a pair, even in the two years covered by the observations.

The following are the measures down to this time:—

1889·19	326·1°	0·91″	β 4n.
1890·26	320·1°	0·87″	β 4n.
1891·30	316·8°	0·80″	β 4n.

It is not unlikely that it may prove to be a rapid binary, and that the distance is now about maximum. In that case a more rapid change in the angle may be looked for soon. It is easily measured with the large telescope when the conditions are good, but with a distance of one-third, or even one-half that given in the measures, it would probably be a severe test for the 36-inch. So far as I know it has not been seen anywhere else, though some of the large refractors ought to show it. I hope to measure it regularly each year for some time to come.

Lick Observatory, *June 2nd.*

ASTRONOMY AS TAUGHT BY ACADEMY PICTURES.

To the Editor of KNOWLEDGE.

SIR,—Will you allow me to say a few words in reply to your notice of my picture of Jeremiah Horrocks in the Royal Academy. Three points are there singled out for animadversion. First you say that I have drawn Venus too small, "the black disc representing Venus should be larger." You do not say how much, so the reader might infer some terrible disproportion in my delineation. May I point out that the major diameter of the Sun's disc in the composition measures one inch and three-quarters, and the minor one about half that size. The sub-division of the former into 30 will give the proportional size of Venus, this being a speck not much, if at all, larger in size than that which I have delineated, keeping in mind the fact that this is a foreshortened perspective view, and not one seen full front, as it would be in a circular diagram. You add that the place of Venus upon the Sun's disc is not quite low enough on the right hand limb. As a fact I have copied it from the sketch to be found in the text of the "Venus in sole visa," left by Horrocks and published by Hevelius.

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You state "there is no authority for the curious equatorial mounting" which I have drawn, "or for the attachment of the sun-screen to the instrument by a rod. In fact, we know that such a mounting could not have been used." My authority is the illustration to be found—rod, screen, and all—in the work published by Padre Scheiner in 1626, called "Rosa Ursina," giving full warrant for its use in Horrocks' time. The telescope is there seen fastened by strings, enabling him to take it off and place it, if need were, as suggested by you, but not necessarily precluding its use in any other manner that might occur to the astronomer who was so full of resources. The clouds, which only dispersed at the late hour of his observation, enabled him to take very deliberate precautions beforehand for his final survey. You say the tube was evidently home made; whether that was the case or not, it was of the best kind, as he states, "The telescope which I employed on this occasion is much more accurate than those generally used," leading to the belief that he probably had more than one of those instruments in his possession. He probably set the telescope to the position it would occupy when he came out of church, as if it had been driven by clock work.

To your final objection as to the omission of the cassock, as part of his dress, I think I must plead to its being done purposely, as I thought its ample folds would have interfered seriously with the movements necessary during his observation in a small room full of the accessories necessary for the fulfilment of his purpose.

Yours very truly,

EYRE CROWE, A.R.A.

[To follow Mr. Eyre Crowe, I would gladly exercise a little poetic imagination, and suppose that Horrocks knew the time within two minutes when he would be able to finish his service and get to his rooms. The Sun appears to move by reason of the earth's daily rotation through its own diameter in about two minutes. Consequently, if Horrocks had had modern facilities for timing his clocks and accurately setting his telescope, he might have hoped to find some portion of the Sun's disc thrown on the screen. But in order that he should enter the room and find the image of the Sun centrally on the screen, as Mr. Eyre Crowe depicts it, Horrocks must either have had a telescope moved by clock work, or he must have moved himself with the precision of very accurate clock work, for he must have entered the room within ten seconds of the time he had intended and calculated for. If this is Mr. Crowe's theory, why did he not give Horrocks' equatorial mounting a divided circle to enable him to set the instrument in right ascension? Scheiner's instrument, as shown in the "*Rosa Ursina*," had such a divided circle about the base of its polar axis, roughly divided it is true, but it would no doubt have enabled him to find a star or the Sun's place within a quarter of an hour.

I did not suggest that equatorial mountings were not used in Horrocks' time. They were certainly in use before telescopes were invented, as is proved by the plates in Tycho Brahe's "*Astronomiæ instauratæ mechanica.*" But such an instrument would have been quite unsuited for use in Horrocks' room. It would have needed to be out in the open, or under a revolving roof, to have enabled Horrocks to watch through the whole day with it. Horrocks says that he commenced watching from sunrise, and went on at every available opportunity through the whole day. But with Mr. Eyre Crowe's mounting he would only have been able to see the Sun as it passed across the parts of the sky visible from the centre of the room through the narrow windows.

Mr. Crowe tells me that I have not said how large the disc of Venus should have been drawn. Horrocks estimated it as about a quarter of an inch in diameter, or a little more. I did not measure Mr. Crowe's picture with a divided rule, but compared the body of Venus with the size of the eye of Horrocks. The diameter of the iris of most people is about three-eighths of an inch, or a very little more. Horrocks' head is not far from the Sun's image, consequently the diameter of Venus ought to have been represented as about two-thirds of the diameter of the iris of Horrocks' eye. But Mr. Crowe represents it as a little round black spot of perhaps a fifth of the diameter of Horrocks' iris, making allowance for the fact that the whole of the iris has not been shown. The disc of Venus ought not to have been circular, but should have been elliptical, like the foreshortened disc of the Sun.

Mr. Crowe says that he has copied Hevelius's diagram, but he has not copied the scale Hevelius gives, which was so carefully drawn by Horrocks. The use of this scale occupied Horrocks' attention during the whole of the observation, and enabled him to measure the diameter of the planet, and to determine its place upon the Sun's disc. Curiously enough, Hevelius's diagram is a little inaccurate. Horrocks was careful to say that he made his divided circle six inches in diameter. Hevelius's diagram is about six and a half inches in diameter.

Mr. Crowe has also given an Artist's rendering of Scheiner's equatorial stand, especially as to the mounting of the octagonal polar axis, which could not have been turned in its bearings as it is drawn by Mr. Crowe.

I hope that my criticisms will not have the effect of deterring Mr. Crowe from again attempting an astronomical subject. I should be delighted to be of service to him if he should again enter the field.—A. C. RANYARD.]

BIRDS AND BERRIES.

By the Rev. ALEX. S. WILSON, M.A., B.Sc.

(*Continued from page* 53.)

THE prevailing colours of succulent fruits are red, blue, purple, orange, and black. White berries are comparatively rare. In this respect the colours of fruits differ from those of flowers. Black, though occasionally seen in violets, is rare in flowers; white, on the other hand, is common. Perhaps the explanation of this difference is to be found in the circumstance that night-blooming flowers are white to suit their nocturnal visitors; whereas, very few frugivorous birds being nocturnal in their habits, we should expect a corresponding absence of pale-coloured fruits. The latter might, however, be readily discovered by fruit-eating bats. If at any particular season we compare the colours of the fruits then ripe with the tints of the flowers in bloom at the same time, we cannot fail to remark the greater uniformity of colour among fruits. Thus the fruits of honeysuckle, wild rose, yew, and holly differ much less in colour from each other than the contemporary flowers.

Notwithstanding this, birds appear to recognise when fruit is ripe by the change of tint it shows. We have seen a rowan-tree stand for days and no birds come near, although it was covered with berries; but, directly these assumed their deep orange tinge, numerous blackbirds appeared and cleared the tree in a single day.

Nature commonly avoids the superfluous. The colour of the fruit in many instances does not extend over its entire surface, but is confined to the exposed side; the concealed portions resembling the foliage by which they

are hidden. Hence the rosy cheek of the apple, peach, &c. In the magnolia we find a remarkable arrangement. Its fruit is dry and contains but one seed. One-seeded fruits do not as a rule open, but themselves become detached from the mother plant, and are dispersed. Magnolia is, however, an exception. Its one-seeded fruit which remains on the branch opens suddenly, and the seed is jerked out; but, instead of falling to the ground, the seed is retained by its long string-like stalk or funiculus, and hangs down outside the capsule. The external portion of the seed is succulent and coloured, resembling that of the pomegranate, and there can therefore be no doubt that the object of thus hanging out the seed is to expose it in such a way that it will readily catch the eye of some bird.

A peculiarity noticed in the raspberry and some others is deserving of mention. The fruit, partially hidden by the leaves, can be seen more readily by a person standing at some distance from the bush than when close beside it. The intention seems to be to discourage birds from settling on the plant and devouring its fruits in quantity on the spot. This peculiarity compels a bird to make more numerous journeys, and secures wider distribution. Further, when the bird is under the necessity of flying to a neighbouring tree to consume the fruit it has got, or to make a survey in search of more, the seeds stand a better chance of being delivered in localities favourable to their development—that is, in situations where birds are in the habit of perching, such as thickets and shaded plantations corresponding to the habitat of the rasp and similar plants. Wind-carried seeds would have very little chance of penetrating these sheltered situations unless of minute size. But the smaller the size of a seed the more scanty is the stock of nourishment it can afford for the development of the embryo during germination. This, to plants which affect a shady habitat, would be a decided disadvantage, and therefore the mass of the seed cannot with safety be reduced below a certain limit.

Succulent coloured fruits are very common in the order Rosaceæ, to which most of our cultivated fruit-trees belong. The apple, pear, medlar, quince, peach, plum, cherry, rasp, and strawberry are members of this order. It is somewhat remarkable that while the fruits of Rosaceæ are thus highly specialised the flowers should belong to a comparatively simple type, having, as a rule, separate petals and exposed honey. In some genera, such as *Alchemilla* and *Poterium*, the flowers appear to have degenerated into the apetalous condition.

Glancing over the list of plants which produce succulent fruits, we observe that these are either trees or shrubs, herbaceous species being almost unrepresented. The same rule evidently applies to fruits which, as we have seen, holds good in the case of flowers requiring the assistance of birds. Fruits of this description produced too near the ground would not only escape the notice of birds but would present a strong temptation to many terrestrial creatures, and attract a host of enemies in no way fitted to help in dissemination. Of this we have convincing evidence in the frequency with which cultivated strawberries are devoured by snails. Like large mellifluous flowers, fruits adapted to birds require to be placed at some distance from the ground, beyond the reach of snails, larvæ, ants, rodents and larger quadrupeds. The prickles and hairs on the stalks and outsides of many flowers are believed to prevent small creeping insects from reaching the nectar. Many of these structures may, however, render more important service in defending the fruit; the prickles of the rasp and bramble would appear to be of use in protecting the fruit quite as much as the flowers and foliage.

Birds in eating succulent fruits may either reject the stones and seeds, or these may be swallowed and pass through the intestines of the bird without losing their germinating power. This ordeal would even seem to benefit some seeds by facilitating their germination. It has at least been asserted, on reliable authority, that nutmegs which are swallowed by pigeons for the sake of the mace, thrive much better if dropped by the birds than when planted by man. Succulent fruits commonly have seeds so hard that they resist the action of the mandibles, gizzard, and stomach of most birds. In drupaceous fruits the seed itself is not hard, but it is enclosed for protection in a woody endocarp or stone. The pomegranate has the testa or outer layer of the seed soft, but the central core is woody; in any case the part ultimately dispersed by the birds is hard. This, in the date and grape, is the seed; in the strawberry and fig, the fruit or achene; in the cherry, rasp and bramble, the endocarp; and in the gooseberry and currant, the indurated core of the seed. Indurated seeds and fruits are not, however, confined to plants which employ birds in the work of dissemination. Mice, squirrels, and other small rodents, consume large numbers of seeds, and where this danger has to be met it is of the highest importance to a plant to possess hard seeds. This is in all probability the explanation of the remarkably hard nutlets of some of the Labiatæ and Boraginaceæ, and of the stone-like seeds called Brazil nuts. The flinty cocci of *Lithospermum* are calculated to give even a rodent the toothache. The glassy grains of *Coix lacryma*, known as Job's tears and used as beads, and the horny albumen of the palm *Phyteleps macrocarpa*, which furnishes vegetable ivory, are marked examples of this excessive hardness.

By accidentally dropping nuts, monkeys and squirrels may occasionally assist in dispersion; but it may be doubted whether this occasional service is a sufficient compensation for the quantities they consume. The nuts themselves, at least, cannot be said to possess any special provision for this mode of dispersion. The strong beaks of the parrot tribe, on the other hand, are well adapted for breaking open hard-shelled fruits of this description.

A disagreeable taste will prevent a seed being eaten by animals or swallowed along with the sweet pulp of the fruit. Such is apparently the meaning of the bitterness of the orange seeds, of one variety of almond, and of the fresh spermoderm of the walnut. *Cocculus indicus*, sometimes used to give bitterness to malt liquors, is the fruit of a plant belonging to the Menispermaceæ. The seeds of fox-glove and mullein are bitter, and those of the upas tree intensely so. In other cases the seed has a hot, pungent taste, as in the mustard and other crucifers. Pepper is obtained from the fruits of various orders; black pepper from *Piper nigrum* (Piperaceæ); Jamaica pepper from *Eugenia pimenta*, a plant of the myrtle family; Cayenne pepper, chillies, bird-pepper and cardamons from various members of the Solanaceæ. From *Nigella sativa* (Ranunculaceæ), *Tasmannia aromatica* (Magnoliaceæ), *Xylopia aromatica* (Anonaceæ), from the Elatinaceæ, or water-peppers, some of the Verbenas, the Polygonaceæ (*Polygonum hydropiper*), and from some plants of the ginger order, pungent or peppery seeds are obtained.

The fruits of the guelder rose, honeysuckle, ivy, dog-mercury, lobelia, and of some of the fox-glove order possess emetic properties, so that in the event of the seeds being swallowed there is a possibility of their being vomited up again. The robin eats the berries of honeysuckle, but vomits them afterwards. The fig and tamarind are examples of laxative fruits, a quality shared to a greater or less degree by most of the succulent class. Many, indeed, are powerful purgatives, such as the colocynth (*Citrullus*

XUM

Colocynthis) (Cucurbitaceæ), the jalap (*Ipomœa purga*) (Convolvulaceæ), *Euphorbia Lathyris*, the croton-oil plant (*Croton Tiglium*), the castor-oil plant (*Ricinus communis*), the physic nut (*Jatropha Curcas*) (Euphorbiaceæ); *Rhamnus catharticus*, *Bromus catharticus*, *B. purgans*, &c.

Emetic and purging seeds are not likely to be retained long enough in an animal's stomach to admit of their germinating power being destroyed.

Narcotic and poisonous properties are not uncommon in seeds and fruits. We have marked examples of this in *Atropa*, *Hyoscyamus*, *Andromeda*, *Strychnos*, and in some of the Apocynaceæ and Umbelliferæ. A seed that occasions the death of any animal that swallows it might be benefited by its poisonous properties if the rich soil furnished by the decaying body of its victim were necessary for its germination. But it is hardly possible that this can be the end intended in all poisonous seeds. If any plant were systematically to poison the birds on which it depended for dispersion one of two things must happen. Either this short-sighted policy would lead to the extermination of its benefactors, or the birds would gradually learn to avoid its fruits. In any case the plant would lose its means of dispersion, and place itself at such a disadvantage in the competition with other species as would in the long run lead to its own extinction. Further, it must be remembered that substances poisonous to man and certain other animals are without effect on certain others. Thus, rabbits eat the leaves, and thrushes the berries, of the deadly nightshade; strychnine is said to have no injurious effects upon monkeys. Poisonous compounds may be formed in plants and occur as accidental qualities, just like the mineral poisons of the inorganic world. It seems improbable that these poisons should be produced in fruits for the purpose of destroying the agents concerned in dispersion. If, however, this should turn out to be the case in some instances, it would after all be no more wonderful than what occurs in such insectivorous plants as Drosera and Dionœa.

Birds are known to eat many poisonous fruits with impunity. The fruits of the manchineel (*Hippomane*) contain a deadly poison, and yet certain birds in South America eat them without injury, just as happens in our own country with the scarlet berries of the honeysuckle. The active principle of castor oil is not found in any part of the seed except the embryo, and the poison in several of the Solanaceæ is said to occur only in the outer covering of the seed and not at all in the pericarp. All parts of Hyoscyamus are more or less poisonous. Its popular name of Henbane arises from the idea that it has a special fatality for hens. This is quite intelligible on the supposition of the poison being concentrated in the outer layers of the seed. On account of the trituration to which the seeds are subjected in the gizzard, they are much more likely to prove fatal to a gallinaceous fowl than to other birds with weaker stomachs.

Such considerations indicate that the use of these poisonous properties may be to prevent the fruits being eaten by animals, which would so thoroughly digest the seeds that their germinating power would be destroyed. The development of poisonous principles in connection with the fruit is probably of use also as a protection against injurious insects. These are very ready to attack fruits in all stages of growth; it is quite conceivable, therefore, that the poisons in berries are primarily intended to act as insecticides, and that later on they come to be of use in keeping away other animals capable of injuring the seeds.

When a poisonous principle first began to be developed in any particular fruit, the birds which fed on it, we should naturally suppose, would become gradually inured to the poison until it completely lost its effect. The liking of parrots for peppercorns, in all probability, is an acquired taste. Immunity from particular poisons might be acquired in the same way as we may suppose the strong mandibles of the parrot have been acquired in relation to hard-shelled fruits. Where poisoning occurs it would seem to be accidental, and should perhaps be regarded as arising from imperfect instincts, or as the inevitable concomitant of a transition stage in development towards more perfect adaptation. On the same principle we should also be disposed to explain the case of those Aroids whose flowers, according to Delpino, poison the snails on which they depend for fertilisation.

(*To be continued.*)

Notices of Books.

Telescope Work for Starlight Evenings. By WILLIAM F. DENNING, F.R.A.S. (London, 1891, Taylor & Francis.) Mr. Denning is so well known as a patient observer of meteors and of comets, that a work from him on observational astronomy will be looked upon with special interest. The plan of the book is somewhat on the lines of the late Mr. Webb's *Celestial Objects for Common Telescopes*; though it does not profess to compete with it in the detailed description of the moon or of stellar objects. One naturally turns first of all to Mr. Denning's chapter on meteors and meteoric observations, which contains some striking pictures of detonating meteors, and of double and curved meteor tracks. The meteor masses which enter the air are occasionally so irregular in shape that the resistance of the atmosphere as they pass quickly through it drives them out of their original course. Mr. Denning says that several outbursts of light are often noted, and sometimes a curious halting motion (which must of course be an optical illusion) has been noticed. He states that he has occasionally remarked a succession of brilliant flashes given by one fireball. These flashes, though sometimes of startling intensity, are somewhat different from the transient vividness of lightning, they come more softly, and Mr. Denning says that they remind him of moonlight breaking suddenly through the clear intervals in passing clouds. Great differences are noted in the velocity of meteors; some move very slowly, while others shoot quickly across the sky. These differences are caused by the astronomical conditions affecting the position of the meteor-orbit relatively to the motion of the earth. Thus the meteors of November 13th move with great velocity (44 miles per second), because they come from the part of the heavens towards which the earth is moving with a speed of 18½ miles per second, while the meteors themselves are moving in nearly a contrary direction with a velocity of 26 miles a second. But in the case of the meteors belonging to the shower of November 27th, the meteors catch up the earth from behind; their relative motion is therefore extremely slow, being only about 10 miles a second. On November 12th, 1799, Humboldt at Cumana, in South America, saw "thousands of bolides and falling stars succeed each other during four hours." On November 12th, 1833, the shower recurred, and was witnessed with magnificent effect in America. It was first noted during this shower that the meteor tracks all seemed to radiate from a point in the heavens; subsequently Heis in Germany, Schmidt at Bonn and Athens, Mr. R. P. Greg and Prof. Alex. Herschel in England, by

continued observations discovered many other radiant points in the heavens from which the meteors which fall at other times of the year appear to radiate. Mr. Denning has most systematically extended the work, until now more than a thousand of such radiant regions in the heavens are known.

Optical Projection, a treatise on the use of the Lantern. By LEWIS WRIGHT (Longman, Green, & Co.) The lantern is becoming more and more widely used by teachers and lecturers, as it enables them to throw upon the screen enlarged images of physical phenomena, and to perform many experiments in the presence of large audiences which formerly could only with difficulty be exhibited to two or three at a time. But one still frequently sees demonstrators who never half develop the powers of their apparatus solely for want of duly considering its optical properties. This does not apply only to itinerant lecturers, but to polarization and other physical phenomena projected with the most elaborate electric-light apparatus at places which may be considered the very headquarters of scientific exposition; experiments are frequently shown in a manner which gives inferior results to those which may be obtained with only oxy-hydrogen illumination. Such a book as Mr. Lewis Wright has given us will therefore be widely welcomed. It deals not only with the optics of the lantern, but with all sorts of lantern accessories, screens, slides, the lime light, the preparation of gases, &c. Several chapters are devoted to descriptions of experiments suitable for projection on the screen, many of which are ingeniously contrived. Mr. Lewis Wright has had large experience in such work, and has for years made it a special hobby. He was already favourably known to us by his excellent text-book on "Light and Experimental Optics," and the present work exhibits equal resource and ingenuity. In projecting the apparatus necessary for experiments, as well as pictures upon the screen, it is not as easy as might at first sight be imagined to arrange for an equal illumination of the field, and that as many rays as possible may be made to fall upon the slide or object, and also to pass through the projecting lens. Mr. Wright has been especially happy in contriving means to this end, suitable for very various classes of experiments, and different degrees of magnification. He states that the preparation of his book was suggested to him by Mr. Herbert C. Newton, with whom he has spent much time in contriving and testing scientific optical apparatus for the use of colleges and public institutions, and the work is in some senses a joint production, Mr. Newton's firm having made this branch of optical manufacture a speciality, have been enabled to offer Mr. Wright special facilities for experiment, and the result is eminently satisfactory.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

THE BRILLIANCY OF DOUBLE STARS.

To the Editor of KNOWLEDGE.

SIR,—Mr. Maunder falls into a mistake in supposing that my formula in *The Observatory*, Vol. X., gives the "mass-brightness" or "candle-power per ton" of a binary star. The proper expression would be "density-brightness," not "mass-brightness," *i.e.*, the relative illumination per unit of surface on the assumption that the stars were, in all cases, globes of equal density. This correction, I think, renders Mr. Maunder's figures rather more favourable to his conclusion, but the error is worth correcting as it occurs in Professor Young's well-known text book, though it will no doubt be rectified in the next edition. According to Mr. Maunder's table, only one Sirian star has a density-brightness lower than the average for Solar stars, while in no case does the density-brightness of a Solar star rise to the average for the Sirian class. I may notice that my figures in *The Observatory* for the two stars λ and τ Ophiuchi were vitiated by an error in the computation. This has been corrected by Mr. Gore.

Dublin, June 6th. W. H. S. MONCK.

REPLY OF MR. MAUNDER.

I am obliged to Mr. Monck for his correction, which I had myself perceived the necessity for almost immediately after I saw my article in type. It is curious how easily one can make and pass over so obvious an error, which looks "gross as a mountain" when the attention is called to it.

My mistake arose from a too natural interpretation of Prof. Young's graphic but misleading expression of "candle-power per ton," which caught my fancy and which I followed up without examination. The process Mr. Monck gave in *The Observatory*, and which Mr. Gore and Prof. Young have adopted from him, gives us the relative brightness per unit of surface, assuming that the two binaries have the same density. As Mr. Monck says, my mistake, however inexcusable, does not vitiate my conclusions; rather the other way. Assuming that the illumination per unit of surface is the same for all stars, and computing the relative density, Mr. Monck's formula gives the average Solar star as fourteen times as dense as the average Sirian star. The net result, therefore, of such materials for comparison between the two types as we at present possess gives the preponderance to the Solar stars in total radiation, in size, and in density; and the more I think over the facts we have before us—meagre enough, I admit—the more I am inclined to consider the generally received interpretation of stellar type as the result of an over hasty generalization, and to consider that difference of type of spectrum most generally indicates an actual difference of constitution.

E. W. MAUNDER.

PERPETUAL CALENDARS.

To the Editor of KNOWLEDGE.

SIR,—Circular Calendars have been numerous. My brother published one fifty years ago, so far as I remember, similar to Mr. Prince's, but smaller. I bought one more than twenty years ago in Paris, a very neat little thing, on white metal, about the size of a two-franc piece, and some ten years since one was described in the *English Mechanic*, consisting of three circles, one being for centuries. The chief drawback to their use is their absence when wanted, and the trouble of referring to the printed addendum to find the Sunday Letter.

The handiest mental rule I have come across, dispensing with all reference whatever, is the following. By its use, I think the week day for any date may be much more readily found than by any circular calendar or similar means.

Rule: From half following Leap Year subtract years past. In other words, from half the next greater multiple of 4, take the remainder on dividing year by 4. Divide by 7; remainder is date of first Sunday in March of given

year. The year of century only must be used. For other months arrange and number them as follows :—

March	April	May	June	July
0	1‡	2	3‡	4
August	September	October	November	December
1	2‡	3	4‡	5
January	February			
2	3‡			

Add the number for the month to that found for March, plus 3 when marked thus‡, reject sevens; remainder is date of first Sunday in given month, from which other days may be found. NOTE.—January and February are the last two months of preceding year; also, that the numbers in second and fourth columns, marked ‡, are 30-day months.

The above is for present century only. For next century add 2; for last century reduce by 2, and generally for any century, new style, divide centuries by 4; twice remainder plus 3, throwing out sevens, gives number to be added.

Old style centuries: To centuries add 5, or subtract 2, and reject sevens.

Examples. 1891. Next following leap year is 92, half is 46; being third after leap year, deduct 3; divide by 7, remainder is 1=date of first Sunday in March. April is 1+1+3=5; May, 1+2=3; June, 1+3+3=7; December, 1+5=6; February, '92, 1+3+3=7, &c., &c.

A.D. 1, O.S. Centuries=0+5=5; year=2—1=1; 5+1=6, date of Sunday in March.

1815, June. Centuries=0; year is 8—3+3+3=11+7=18th, a Sunday.

Yours truly,
C. LUND, Ilkley.

To the Editor of KNOWLEDGE.

SIR,—I was very pleased with, and greatly interested in, Mr. Hutchinson's article on "The Cause of Volcanic Action," which appeared in the current month's issue of KNOWLEDGE. But there is one point upon which I should feel extremely obliged if Mr. Hutchinson would give a little further information. On page 106 he says, "A much more promising explanation is that there are below the crust of the earth large masses of highly heated rock, kept solid by the enormous pressure of overlying rocks; and when earth-movements take place within the crust, such as the upheaving of a mountain chain, taking off some of the weight, the balance of pressure is no longer maintained, and so the highly heated rock runs off in a liquid state, and finds its way to the surface, producing volcanic action." I should like to ask, am I right in assuming that the above explanation refers only to the original formation of volcanos, and if so, what is the disturbing cause in the case of Vesuvius, Etna, and other mountains, which have longer or shorter periods of quiescence, and when active are not associated (as far as I am aware) with earth-movements such as the upheaval of mountain chains? In the theory propounded by Bischoff (who, I think, believed the centre of the earth to be in a molten state), water is the great factor as a disturbing cause. It also plays a very great part in the theory (chemical changes) propounded by Sir Humphry Davy, who held the opposite view with regard to the earth's interior. Hoping, sir, that you will kindly find a corner for this request in your next issue,

I remain, yours faithfully,
H. CHRISTOPHER.

[A scientific theory which is "not proven" must necessarily leave room for some difficulties. I think it was Wellington who said the best general was the one who made the fewest mistakes. So with scientific theories—that one is the best which presents the fewest difficulties. The question raised by Mr. Christopher is not easily answered. The explanation of volcanic action referred to in my paper applies to the original formation of volcanos, and explains their association with mountain chains; but, at the same time, I conceive that it also applies to the case of Vesuvius and other volcanos now in eruption, which do not appear to him to be associated with the upheaval of mountain chains. But in reality they are so associated. The upheaval of the mountain chain was the cause which brought them into existence, and, having once begun their activities, they go on for a long period—probably until the balance of pressure below has been restored by the creeping of heated rocky matter in that direction. Vesuvius will go on as long as such matter is slowly impelled to its neighbourhood, just as water will squirt out of an indiarubber ball as long as you squeeze it. When other earth-movements start somewhere else the movement may take place towards some other line of upheaval which at present does not exist. This does not necessarily imply the presence of molten rock below, but only of rock sufficiently heated and viscous to creep along as clay or putty would under pressure. I cannot believe that water is the disturbing cause, for it must be present in considerable quantity in all subterranean regions. Lastly, a very little disturbance of the earth's crust may suffice to alter the balance of pressure below.—H. N. HUTCHINSON.]

To the Editor of KNOWLEDGE.

SIR,—No doubt most of your readers have been favoured, at some period of their life, with a proof that one is equal to two. Perhaps the enclosed view of the matter may be equally convincing.

Yours faithfully,
R. CHARTRES.

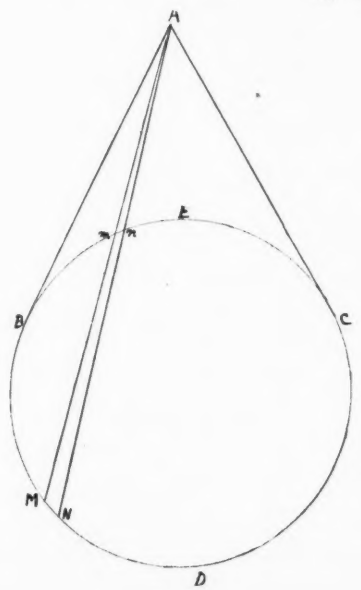


Fig. I.

Let B E C D be a section of a thin spherical shell, and A B C a section of a cone touching the shell.

It is easily seen that the attraction of the lower part B D C on A is exactly equal to that of the upper part B E C. Therefore, the attraction of the whole shell will

be double that of the lower part B D C. Now, let A gradually approach the shell, then the lower part B D C gets larger, but the attraction of the shell is still double of it; and ultimately, when A coincides with E, the attraction of the shell is double of itself. R. CHARTRES.

[This is perhaps too difficult for some of the readers of KNOWLEDGE, who may welcome a word of explanation.

The attraction of the lower part of the spherical shell B D C on a particle at A may be shown to be equal to the attraction of the upper part B E C, which lies within the enveloping cone B A C, by considering the attractions of the small portions of the thin shell cut out by a cone of very small angle with its vertex at A. We have M N is to $m\ n$ as A N is to A n, and the portion of the thin spherical shell intercepted at M N is to the portion intercepted at $m\ n$ as A N^2 is to A n^2. But the attractions on the particle at A are inversely as the square of the distance from A. Therefore, the portions intercepted on the nearer and further side of the shell will attract the particle at A equally. Hence,

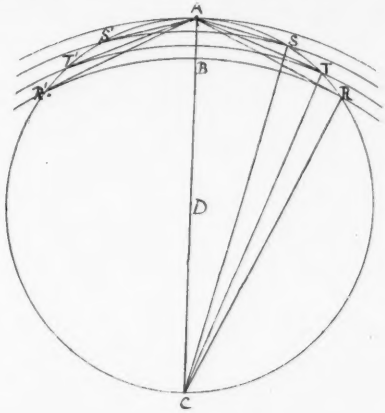


Fig. II.

the whole exterior portion B D C attracts a particle at A equally with the interior portion B E C. But this is only true for a shell the thickness of which vanishes compared with the distance of A from the shell. In the case of a particle approaching and ultimately resting on a shell of sensible thickness—we may determine the attraction by considering the shell as composed of a number of very thin concentric strata. In Fig. II. let S S', T T', R R' represent thin concentric strata, with centre C, the particle being at A. Bisect A C in D, and with centre D describe the circle A S T R C. Then A S, A T, A R will be tangents to the circles S S', T T' and R R', for the angles A S C, A T C and A R C are all right angles, since the points S T R lie on a semi-circle with diameter A C. The attraction of the portion of the thin spherical stratum R R' within the enveloping cone will be equal to the attraction of the whole of the rest of the stratum, and so for any other thin stratum T T' or S S'; consequently, for a shell of sensible thickness, the attraction of the material within the small sphere A S T R C R' T' S' will be equal to the attraction of the whole of the rest of the shell.

In the case discussed by Mr. Chartres, when the spherical shell is thin there will be very little attracting matter within the smaller sphere described on the radius of the larger sphere as diameter, but as this matter is close to A the intensity of the attracting action will be considerable, and will balance the attracting action of the rest of the shell.—A. C. RANYARD.]

THE POTATO FUNGUS.

By J. PENTLAND SMITH, M.A., B.Sc., &c., Lecturer on Botany, Horticultural College, Swanley.

IN the "Travels and Life-History of a Fungus," chronicled in the June number of KNOWLEDGE, the nature of those lowly organisms termed Fungi was briefly sketched. The example then selected had an extremely interesting and complex life-history, but the reader will probably acknowledge that the form which is brought before his notice in this paper has an equally romantic story to tell. Its ravages have been the subject of much discussion lately in connection with the distress prevalent amongst the Irish peasantry, but that was not the first time that it had occupied the attention of the public and Parliament in this country. In fact, to quote the words of Dr. Plowright, in a lecture delivered lately at the Royal College of Surgeons, and reported in the *Gardeners' Chronicle*, "of all the plant diseases of fungoid origin, there is none which has aroused more general interest than that caused by the parasitic Fungus, known to scientists as *Phytophthora infestans*. This is one of the very few Fungi which can claim to having effected a change in the laws of our land. Politicians and reformers take credit to themselves for having, by dint of much writing and more talking, brought about the repeal of the corn laws, but there are those who still say, if it had not been for the Potato disease and the famine it caused in Ireland, this political change would not have taken place until long after it really did."

It was in 1845 that the first attack general over Great Britain and Ireland was noticed, but more localised attacks in this and neighbouring lands had been chronicled in previous years; they, however, were so slight as not to attract much attention. "So momentous a calamity as befell Great Britain and Ireland," says Dr. Plowright, "by the failure of the potato crop has seldom been equalled, and is quite without parallel in the records of food-supply in our time."

The Potato (*Solanum tuberosum*) belongs to the Natural Order, or group of plants, *Solanaceæ*. Its native place is the Cordilleras of Chili, and perhaps of Peru. Its parasite in this country doubtless attacked it in its native wilds. It is now upwards of 300 years since it was introduced into Europe, first by the Spaniards and afterwards by Raleigh, but until half a century ago no appearance of the *Phytophthora infestans* was noticed. We reserve a probable explanation of this curious circumstance until the description of the fungus itself.

During July and August, especially in sultry, damp weather, a pestiferous, sickening odour may be observed to arise from the potato-fields. An examination of the plants shows that they are evidently in a diseased state. The leaves are curled up, and they and the stems have a blackened appearance. This condition is the result of a visit of *Phytophthora infestans*. The first indication of the presence of the fungus is the appearance of dark patches on the leaves, then circular or oval patches of a whitish bloom arise as if by magic on the under surface of the leaves. Microscopic investigation reveals the cause to be of a fungoid nature. If the meteoric conditions are favourable for the further growth of the fungus the field of potatoes may be a blackened, putrescent mass in a few days.

Figure I. is a semi-diagrammatic transverse section of a Tomato-leaf. The Tomato (*Lycopersicum esculentum*) belongs to the same natural order as the potato, and like it, especially when grown out of doors, is extremely liable to the attacks of

XUM

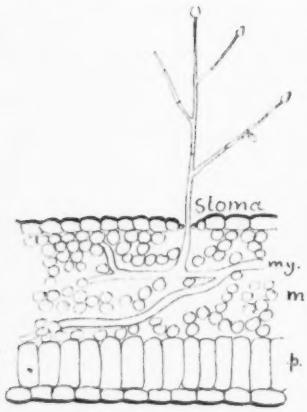


FIG. I.—Transverse section of leaf of tomato (semi-diagrammatic). The leaf is upside down. The mycelium (*m y*) of *Phytophthora infestans* is ramifying through the mesophyll tissue (*m*), and a gonidium bearing branch has found exit at a stoma.

this fungus, as the writer witnessed here last year. Other plants (such as the henbane) found in this order, are also subject to its attack. The natural position of the leaf is reversed, so that the under surface is uppermost. A thin stalk, which branches in the external medium, issues from a stoma. Ramifying between the mesophyll (middle-leaf tissue) cells are thread-like bodies connected with this branched stalk. The latter, in fact, is merely a prolongation of these threads. They are the hyphæ of the fungus mycelium* which nourishes itself at the expense of the nutrient matter in the cells of the plant, and induces the putrefactive action that may ultimately result in the total decomposition of the whole plant. This fungus is thus distinctly a parasite. The mycelium penetrates the cells by means of small processes, *haustoria*, or suckers; they seem to have a putrefactive action. The blocking up of the stomata or transpiring organs of the plant prevents free evaporation of water, and so hastens the decay initiated by the haustoria. The branching filament figured as proceeding from the stoma is only one of myriads that may be found on one plant. It is divided by a number of transverse divisions, and on the ends of some of the branches, as well as on the main stem, oval bodies are represented. Reference to Figure II. will show these more distinctly. The manner of growth of this branched stalk merits description. On the end of the stalk and of its branches a swelling appears, and is cut off in each case from the stem on which it arises by a transverse septum. The bodies so produced are reproductive cells as we shall presently see, and hence are termed *gonidia*. A slight swelling appears on the stalks below each gonidium, and afterwards growth in length takes place, the result being that the gonidia are pushed aside and stand almost at right angles to their pedicels. These prolongation pedicels repeat what has already been described, and so on.

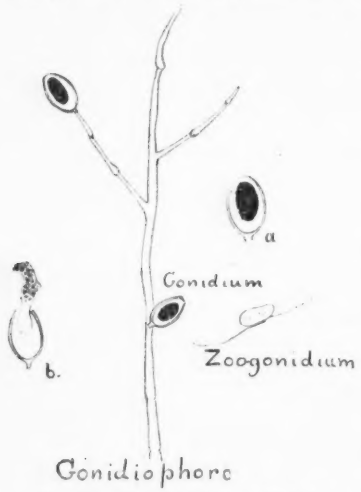


FIG. II.—More highly magnified view of gonidium bearing shoot (*ad nat.*). *a*. A single gonidium (still more highly magnified); *b*, the same germinating.

A warm, humid atmosphere is especially favourable to the development of these organs. This can easily be shown by transferring a leaf with a poorly developed gonidiophore (gonidium-bearing branch) from a comparatively dry and cool medium to a bell-jar standing on water and situated in a warm room. A rich crop of gonidia is the result. These can live for three weeks in an atmosphere not perfectly dry. They are capable of germination in the presence of moisture. In germination the wall of the gonidium ruptures, and the protoplasm, enclosed in a very delicate membrane, protrudes as a small tube, which evidently secretes a ferment, for it can force its way through the cuticle of the epidermal cells of the leaf and thus find entrance into its interior. Once there it ramifies amongst the cells, absorbing their nourishment, and acting in every way like the parent from which it arose. If it be remembered that the gonidia may be present in countless numbers, the quick spread of the disease is easily accounted for.

In addition to this method of increase there is another asexual one. It generally happens that when plenty of moisture is present the protoplasm of the gonidia breaks up into eight pieces, each of which becomes more or less rounded off from its neighbour. The gonidium is now equivalent to a sporangium or spore-containing vessel, but as its contents have arisen asexually the term gonidangium is more applicable. In germination each portion of protoplasm sallies forth from the vesicle as an exceedingly minute body, furnished with two vibratile processes termed cilia, which are merely prolongations of its substance. Such bodies are called zoogonidia, on account of their capability of active movement. This they exhibit only in water or a nutritive fluid. They seem like animals, as they move rapidly about from place to place in the watery medium. Their exit from the gonidangium is prepared for by the swelling of the gelatinous apex of that body, and its almost simultaneous disappearance. At the same time the zoogonidia themselves absorb water, but their extrusion from the vesicle is directly caused by the swelling of the clear gelatinous inner wall of that body, and probably also of the clear layer that surrounds each zoogonidium. These bodies can live, and only in water, a very short time.

Suppose a few potato-plants in a large field of potatoes to be attacked by this pest, it is perfectly evident that the production of myriad zoogonidia on these during a damp, warm day will cause the rapid spread of the disease. For the smallest particle of moisture in the air affords a sufficient quantity of water for these minute bodies to live in. The passage of a dog or other animal through the field, and the visits of birds and insects, facilitate the spread of this dreadful pest.

The zoogonidia, if they find a suitable resting-place, at once germinate. This process, as a rule, takes place on the surface of a leaf. The cilia disappear, and a short tube is sent forth. Like that of the parent gonidium, it can pierce the epidermal cell-wall, and thus enter the leaf-substance. In the leaf it increases in length and branches like the parent mycelium. The hyphæ so formed produce gonidia and zoogonidia in their turn, and so the reproduction of the fungus may take place more than once in the course of a single summer.

Not only does the fungus affect the leaf, but it may enter the stem and even penetrate into the tubers. Moreover, in the young state the tubers are subject to the invasion of the gonidia and zoogonidia, to the former especially if they lie exposed on the surface of the soil. The latter, in certain soils, and in the presence of mois-

* For explanation of terms see "The Travels and Life-History of a Fungus," KNOWLEDGE, June, 1891.

ture, easily find their way to the young tubers beneath. The cuticle of these is so delicate that it affords no barrier to the entrance of the gonidial-tube.

According to De Bary, the processes described are the only means by which the fungus can reproduce itself, and the reader will doubtless be of opinion that such means are ample. A few years ago, however, Mr. Worthington Smith described the formation of sexual organs, and his observations were corroborated by other workers in this department of Botany. In leaves of the potato, towards the late autumn, and in diseased tubers, the products of the sexual organs are, as a rule, plentiful. A small branch of the mycelium, in one of the intercellular spaces, swells up in a globular fashion, and is cut off by a septum (division) from the rest of the hypha, to which, however, it is st ll completely adherent. On the same, or on a neighbouring hypha, a tubular protuberance arises which applies itself to the swelling just mentioned. Its contents are also divided from those of the rest of the hypha by a membranous partition. The first formed body is called the *oogonium*, or egg producing apparatus, the latter is the *pollenodium* (οἰδα, like) for a reason presently obvious (see Fig. III.). Both are densely filled with protoplasm. That of the oogonium divides into two parts, an inner more granular portion surrounded by a clear, delicate, cell wall, and called the ovum, or egg, and an outer less granular case the *periplasm* (περι, around, and πλασμα, a thing moulded). The protoplasm of the pollenodium exhibits differentiation of a like kind, although not so markedly. The ovum before fertilization has received the name oosphere. Where the pollenodium touches the oogonium, a small tube is sent out, which penetrates that organ and so reaches the *oosphere*. Then the central part of the pollenodium's protoplasm, the *gonoplasm* (γεννάω, to produce), is poured into the oospore, which is now called a fertilized egg, or *oospore*. The connection between the oogonium and the parent mycelium now ceases, and changes immediately take place in the former. A wall of cellulose is formed round the oospore, the periplasm contracts, and the wall of the oogonium remains as a covering until germination takes place. The oospore is a little spore, and the sac containing it, previously the female reproductive oogonium, is now a sporangium (Fig. III.).

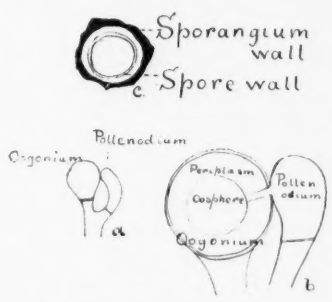


FIG. III.—The reproductive organs of *Phytophthora infestans* (?). *a* and *b*, diagrammatic, *c* (*ad nat.*).

The spore does not germinate at once. Ten months elapse before this can take place. The product of germination is one or more germ-tubes, which behave exactly like those of the gonidia; or the spore, like the gonidium, breaks up into a number of moving bodies, each furnished with two cilia, and so comparable to the zoogonidia. These are called zoospores, because their parent was a spore.

If we adopt Mr. Worthington Smith's view of the case, the spores are the resting stage of the fungus. It is almost impossible in any case to imagine that the mycelium is perennial in the tubers, that is, that it can live in these more than one year, when we know its putrefactive action on their cells. Yet it has been held by some that the mycelium is perennial. At present, however, the matter may be considered *sub-judice*.

The oogonia and pollenodia described by Mr. Worthington Smith have been held to belong to an allied fungus, a species of pythium. Dr. Plowright's remarks, in the lecture already referred to, are interesting in this connection: "All of us who have studied the potato disease have hunted for these resting spores. A few years ago, Mr. W. G. Smith thought he had found them, and most of us thought so too, but it was subsequently shown by the late Professor De Bary, that spores closely resembling Smith's resting spores, very commonly occurred in potato plants kept in damp situations, which belonged to a species of pythium. Since this time we have been unable to meet with a sexual spore, which upon germination is capable of giving rise to the phytophthora, and although the probability is that such a spore does exist, yet there the matter rests."

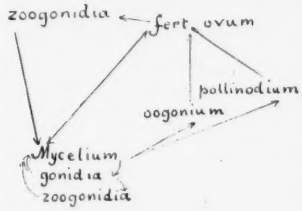


FIG. IV.—Diagrammatic representatives of life-history of *Phytophthora infestans* (the potato-disease fungus).

The temperature of the air has a great influence on the development of this fungus. Above 77° F. the mycelium is killed, and below 40° F. the production of gonidia ceases. About 70° F. may be reckoned as the most productive temperature. In its native place, as we formerly remarked, the potato was undoubtedly attacked by this parasite, although for well-nigh 300 years it had not made its appearance in Europe. It has been affirmed that the high temperature of the regions surrounding its native habitat, localised that of the phytophthora, and also that in passing through the torrid zone any infected tubers were sterilized, that is, were completely ridded of their dread enemy. Nowadays, steamers have replaced sailing vessels, making the passage through the torrid zone of exceedingly short duration, so that the fungus is not killed in the transit of the potato from Chili to Europe. Doubtless also, the same authority remarks, the guano trade has done much to further the spread of this pest, whose life-history can be seen at a glance by reference to Figure IV.

THE FACE OF THE SKY FOR JULY.

By HERBERT SADLER, F.R.A.S.

THE solar surface is still active. Until about the 20th of the month there is no real night in the British Islands. The following are conveniently observable times of the minima of some Algol type variables (*cf.* "Face of the Sky" for June): Algol.—July 16th, 0h. 33m. A.M.; July 19th, 9h. 22m. P.M. δ Libræ.—July 4th, 11h. 8m. P.M.; July 11th, 10h. 43m. P.M.; July 18th, 10h. 17m. P.M.; July 25th, 9h. 51m. P.M. U Coronæ.—July 28th, 11h. 10m. P.M. U Ophiuchi.—July 5th, 11h. 0m. P.M.; July 10th, 11h. 47m. P.M.; July 16th, 0h. 32m. A.M.; July 26th, 10h. 12m. P.M.; July 31st, 10h. 57m. P.M. Y Cygni, July 2nd, 9h. 12m. P.M.; July 5th, 9h. 7m. P.M.; July 8th, 9h. 2m. P.M.; July 11th, 8h. 57m. P.M.; July 14th, 8h. 51m. P.M. Variable of short period, not of Algol type. η Aquilæ.—July 5th, 1h. A.M. Maximum of S Ursæ Majorii (*cf.* Mr. Peek's paper in KNOWLEDGE for March, 1890) on July 24th.

Mercury is not favourably situated for observation in

July, being in superior conjunction with the Sun on the 7th. During the latter part of the month he is an evening star, setting on the 31st at 8h. 41m. P.M., or 54m. after the Sun, with an apparent diameter of $5\frac{3}{4}''$ and a northern declination of 12°, about $\frac{3}{4}$ of the disc being illuminated. Venus is a morning star, but is not a particularly attractive object in the telescope during the month. On the 1st she rises at 2h. 24m. A.M., or 1h. 24m. before the Sun, with an apparent diameter of $10\frac{1}{2}''$ and a northern declination of 22° 18′, about $\frac{93}{100}$ of the disc being then illuminated. On the 31st she rises at 3h. 7m. A.M., or 1h. 17m. before the Sun, with an apparent diameter of 10″ and a northern declination of 21° 32′, $\frac{97}{100}$ of the disc being then illuminated. During the month she passes through part of Taurus and nearly the whole of Gemini. Mars is invisible. But for her great southern declination, Vesta would still be excellently placed for observation, southing on the 5th at 11h. $1\frac{1}{2}$m. P.M., with a southern declination of 21° 38′, and on the 29th at 9h. 13m. P.M., with a southern declination of 23° 20′. She continues to be visible to the naked eye throughout the whole of July.

Jupiter is an evening star, rising on the 1st at 11h. 5m. P.M., with a southern declination of 5° 59′ and an apparent equatorial diameter of $43\frac{1}{4}''$. On the 31st he rises at 9h. 6m. P.M., with a southern declination of 6° 22′ and an apparent equatorial diameter of 47″. He describes a very short retrograde path in Aquarius during the month, and on the night of the 28th is about 14′ north of the $6\frac{1}{2}$ mag. star B.A.C. 8129. The following phenomena of the satellites occur before midnight, while Jupiter is more than 8° above and the Sun 8° below the horizon :—On the 15th, a transit egress of the shadow of the first satellite at 11h. 14m. On the 22nd, a transit ingress of the shadow of the first satellite at 10h. 49m.; a transit egress of the third satellite at 11h. 25m.; a transit ingress of the first satellite at 11h. 51m. An eclipse reappearance of the fourth satellite on the 23rd at 11h. 11m. 38s.; an occultation reappearance of the first satellite at 11h. 20m. On the 29th, an eclipse disappearance of the second satellite at 11h. 5m. 23s.; a transit egress of the shadow of the third satellite at 11h. 24m., and a transit ingress of the satellite itself 14m. later. On the 31st, a transit egress of the second satellite at 10h. 10m.; and a transit egress of the first satellite at 10h. 21m.

Saturn is so rapidly nearing the west that we only give an ephemeris for the first half of July. Saturn sets on the 1st at 11h. 9m. P.M., with a northern declination of 8° 44′ and an apparent equatorial diameter of 16·6″ (the major axis of the ring-system being $38\frac{1}{4}''$ in diameter, and the minor axis 3″). On the 16th he sets at 10h. 11m. P.M., with a northern declination of 8° 13′ and an apparent equatorial diameter of $16\frac{1}{4}''$ (the major axis of the ring-system being $37\frac{1}{2}''$ in diameter and the minor $2\frac{1}{2}''$). During this time he describes a short direct path in Leo. Iapetus is at his greatest western elongation, when he is brightest, on the 13th. Uranus is an evening star, rising on the 1st at 1h. 51m. P.M., with a southern declination of 10° 1′ and an apparent diameter of 3·6″. On the 31st he sets at 10h. 19m. P.M., with a southern declination of 10° 8′. He is in quadrature with the Sun on the 20th, and is almost stationary to the N.N.E. of 86 Virginis during July. Neptune is invisible.

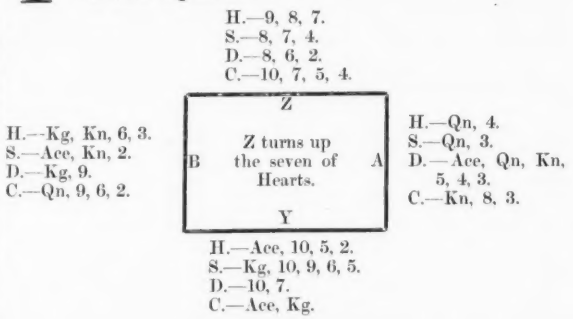
Shooting stars are fairly numerous in July, though the twilight interferes with observation. A well-marked shower radiates from near δ Aquarii, the maximum being on the 28th. The radiant point is in 22h. 40m.—13°.

The Moon is new at 3h. 59m. A.M. on the 6th; enters her first quarter at 5h. 29m. A.M. on the 14th; is full at 1h. 54m. P.M. on the 21st; and enters her last quarter at 4h. 33m. A.M. on the 28th. She is in apogee at 6h. P.M. on the 11th (distance from the earth, 251,610 miles); and in perigee at 5h. P.M. on the 23rd (distance from the earth, 224,325 miles). The greatest western librations take place at 5h. 44m. A.M. on the 4th, and at 5h. 24m. P.M. on the 30th; and the greatest eastern at 9h. 16m. P.M. on the 17th.

Whist Column.

By W. MONTAGU GATTIE, B.A.Oxon.

THE following is an elementary explanation of the play of the hand published last month. For convenience of reference, the distribution of the cards is here repeated :—



Score — Love all.

Tricks 1 *and* 2.—Holding more than four diamonds, A rightly follows the ace with the knave; with four only, he would lead the ace and then the queen. Y can place the queen in A's hand; and the cards played by B and Z show that A also has the five, four, and three of diamonds, unless B is calling for trumps, in which case he may have one small diamond. The only diamond Z can have left is clearly the eight.

Trick 3.—B holds four trumps to two honours, and his partner's diamonds are established. Under these circumstances he does right in opening trumps.

Trick 4.—Y, of course, opens his long suit of spades. He infers from the fall of the cards that B has the knave, for, if either Z or A had had it, he would have played it.

Trick 5.—A returns his partner's trump lead. It is worth noticing (although the inference is not of service in this particular hand) that Y can now place the remaining trumps. This will readily be perceived if it be remembered that A would return the higher of two remaining cards, and that B's lead and subsequent play show four trumps to the king.

Trick 6.—B cannot yet tell whether his partner is void of trumps or has two more; but in either case he plays correctly in continuing them. A, having to discard, disposes of his worthless spade.

Trick 7.—It will be seen that A B have now shown "two by honours," and have already secured five tricks; therefore they require four more tricks to make the game. B is protected in clubs, and has command of the adverse spades, and, if he had another diamond, he could not do better than to lead his losing trump; for, on recovering the lead, he would play the diamond, and, trumps being out, A would make all the remaining diamonds. B, however, has not a diamond, and therefore A's winning cards in that suit will be of no use unless he has a card of re-entry. The king of spades is, in all likelihood, with Y, so that the

best chance is that A may be able to take a trick in clubs. Suppose, now, that A holds the king of clubs, and that Y has the ace. If B follows the rule and leads a small club from his four cards in that suit, the king will fall to the adverse ace, and A's prospect of bringing in his diamonds will be at an end. But, if B leads his queen of clubs, as though he had only three of the suit, the queen will draw the ace, and A's king will enable him to win the game. Of course A may not have any strong club, but in that event B cannot expect to make four more tricks, and he is, at the most, sacrificing one trick in making a bid for the game.

Trick 8.—Y has the winning trump; but he could not tell from trick 4 whether B or A had the ace of spades. He therefore reserves his trump to ruff A's diamonds, in case the ace of spades should be with A. B finesses the knave of spades as a matter of course (see trick 4), and A, equally of course, discards a diamond, so as to keep his knave of clubs guarded.

Trick 9.—B pursues the same tactics as at trick 7, and it will be observed that he has now so far succeeded in his object that A's knave of clubs is cleared.

Trick 10.—Y sums up the situation as follows:—Of five spades unplayed, he himself holds three; and, as B must have the ace, Z can only have one (the eight). If B has both ace and eight (which in strictness should not be, for in that case he ought to have finessed the eight at trick 8, seeing that Z could play nothing better than the seven at trick 4), Y can be sure of saving the game by making a spade. But, supposing that Z has the eight of spades and also the eight of diamonds (see note to tricks **1** and 2), he cannot have any more of either suit, so that he must have at least two clubs. B, having followed the queen of clubs with the nine, is not to be credited with either knave or ten; and, as A must have at least three diamonds, he can only have one club, so that one of Z's clubs must be either knave or ten. He should not hold both knave and ten, as, in such case, he ought to have covered B's nine; therefore either knave or ten may be placed in A's hand. In the former case it will be fatal for Y to draw the losing trump from B, for A will win all the remaining tricks; but, if Y retains his trump to ruff the knave, B, after winning trick 12 with the smaller trump, will have to lead a club, and the last trick will fall to Z. If the knave of clubs should turn out to be with Z, Y Z would perhaps make another trick by Y's drawing the trump, but this possibility is not worth consideration against the certainty that, in the other event, the game would be lost.

Chess Column.

By C. D. Locock, B.A.Oxon.

To Correspondents.—All communications for this column should be addressed "*Cintra, Hawkhurst,*" and posted *before* the 10th of each month. For the words "Chess Problem Tournament" in our last issue, "Problem *Solution* Tournament," should be read. It is not *necessary*, therefore, for competitors to compose or send problems. They are merely invited to send original problems (not more than one by each competitor can be inserted).

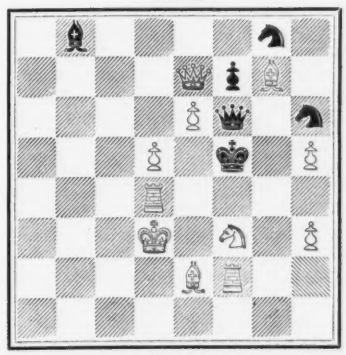
The Solution Tourney begins with the problem below. The conditions of the competition were fully set forth in the June number.

Solution of Problem in June number: 1. K. to R4, and mates next move. Correct solution from C. T. Blanshard.

PROBLEM.

By W. E. Bolland.

Black.



White.

White to play, and mate in two moves.

The Championship Tournament of the City of London Chess Club has again been won by Mr. R. Loman, the well-known musician, who defeated Mr. Moriau in the final tie, after a close contest.

The following game was played on May 13th, in the match between the British and City of London Chess Clubs:—

King's Gambit Declined.

White. G. T. Heppell (City).	Black. H. W. Trenchard (B.C.C.).
1. P to K4	1. P to K4
2. P to KB4	2. P to Q4
3. Kt to KB3 (*a*)	3. P × KP
4. Kt × P	4. Kt to QB3 (*b*)
5. B to Kt5	5. B to Q2
6. Q to R5 (*c*)	6. P to KKt3
7. Kt × Kt	7. P × Q (*d*)
8. Kt × Q	8. R × Kt (*e*)
9. Kt to B3	9. Kt to B3
10. P to QKt3	10. B to QKt5 (*f*)
11. B × B ch (*g*)	11. R × B
12. B to Kt2	12. Castles (*h*)
13. Castles (Q side) (*i*)	13. KR to Qsq (*j*)
14. P to KR3 (*k*)	14. B × Kt
15. B × B	15. Kt to Q4
16. KR to Ksq (*l*)	16. Kt × B
17. P × Kt	17. R × R ch
18. R × R	18. R × R ch
19. K × R (see Diagram)	19. P to R5 (*m*)
20. K to K2	20. P to KB4
21. P to B4 (*n*)	21. K to B2
22. P to R3 (?)	22. K to K3
23. K to K3	23. K to Q3
24. K to Q4	24. K to B3
25. P to B3	25. K to Kt3 (*o*)
26. K to K3 ? (*p*)	26. K to B4
27. K to K2	27. P to QR4
28. P to R4	28. P to B3
29. K to K3	29. P to Kt3
30. K to K2	30. P to Kt4
31. RP × P	31. P × P
32. P × P	32. K × P
33. K to K3	33. P to R5
34. P × P ch	34. K × P
35. K to Q4	35. K to Kt4
36. K to K3	36. K to B5
37. K to Q2	37. K to Kt6
38. Resigns (*q*)	

NOTES.

(*a*) At least as good as the usual P×P.

(*b*) Not so good as B to K3, preventing B to B4, for White can now get a slight advantage by Kt×Kt.

(*c*) The combination is not quite sound. Kt×B is probably better.

(*d*) P×Kt might lead to the following continuation: 8. Q to K5 ch, Q to K2; 9. Q×R, Kt to B3; 10. B to R6!, B to Bsq!; 11. B×B or B to K2, followed by P to KKt4 saving the Queen.

(*e*) Overlooking the winning advantage to be obtained by 8. . . . B×B; 9. Kt×KtP (the Bishop if attacked retires to QR3) 9. . . P to QR4!; 10. P to Q4 (he must make a square for the Kt); 10. . . . P×P *en passant*; 11. B to Q2, P×P; 12. Kt to R3, B×Kt, followed by B to B3, B×P and B to K5. Or if White play instead 11. B to K3, there follows equally 11. . . . P×P; 12. Kt to B3, B to B3, and 13. B×P, with two Pawns ahead at least for the time.

(*f*) The Bishop is best where he is for the present. He should play R to KKtsq; and if then 11. P to Kt3, P to R5, quickly breaking up White's position on the King's side.

(*g*) Of course he dare not play B to Kt2 at once, on account of the reply B×B, winning a Pawn.

(*h*) Again R to Ktsq is much better (*vide* note *f*). The King is best in the centre of the board.

(*i*) It is necessary to defend the KBP.

(*j*) For now Black could at once obtain a passed Pawn by B×Kt, 14. B×B, Kt to Q4, &c.

(*k*) Very weak. KR to KBsq was essential.

(*l*) The other Rook should be played to this square, in order to avoid the exchanges. Obviously Black dare not play to win a Pawn.

(*m*) A fine move, blocking the Pawn position, and leaving two moves for his other KRP to gain time with if necessary.

(*n*) This and his next move are grave errors. The Pawns should not be moved till necessary; and especially the RP, which has the option of moving one or two squares later on, according to need. He should simply come out with the King.

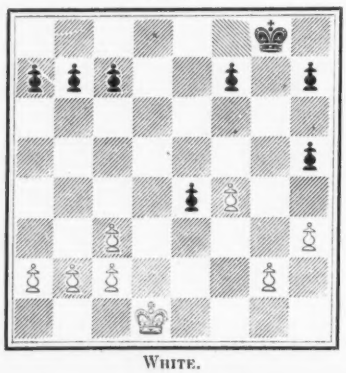
(*o*) Black wisely refrains from moving any of his Pawns till, by doing so, he can force the position.

(*p*) Unaccountable. P to B5 ch (if not any other move) would almost certainly draw. The rest now is easy for Black.

(*q*) For Black can gain the opposition by moving the RP; *vide* note (*m*). The ending is very well played by Mr. Trenchard.

Position after White's 19th move.

BLACK.



WHITE.

KNIGHTS AND BISHOPS.

It is generally admitted that these pieces are of about the same value, but it may not strike everyone on what grounds this conclusion is based. The two pieces have absolutely nothing in common, so that mathematical accuracy of valuation is out of the question. A Bishop's action is like that of a rifle-bullet at long range, direct and swift: a Knight's more like a bomb-shell, explosive in all directions. Most players have a preference for one piece or the other: "Winawer's Knights" are almost as proverbial as "Paulsen's Bishops"; the move, B×Kt. (if possible, doubling a Pawn) being known to the profession as "Winawer's Trade Mark." Mr. Steinitz prefers the Bishop, holding with the ancient dictum that six Bishops are worth seven Knights. Most amateurs, we fancy, have a lurking partiality for the Knight. There is a certain fascination in calculating how many moves it will take a Knight to reach a particular square: the calculation has the merit of combining depth with easiness. The Bishop is in reality a more difficult piece to manœuvre well.

But how are their values to be compared? Take first a simpler case, that of Rook and Bishop. The Rook has obviously five distinct advantages. (1) On a clear board it commands 14 squares from any position; whereas, the Bishop commands its maximum of 13 squares, only if placed on one of the four centre squares. (2) A Rook can, if necessary, command any square on the board; a Bishop is, of course, limited to the squares of one colour. (3) A Rook can confine a King, a Bishop cannot. (4) Rook and King can mate, Bishop and King cannot. (5) Rook assists King to castle. Against all this is to be set the Bishop's one advantage, the power of being brought earlier into play. A Rook, therefore, is evidently far stronger than a Bishop. Going back, now, to the case of Knight and Bishop, we find that points (3), (4) and (5) are not available for comparison. Points (1) and (2) may be discussed first, and then the other respective advantages of the two pieces must be simply counted up, and, when possible, balanced one against the other.

(*To be continued.*)

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For all places outside the Postal Union, 5 shillings in addition to the postage.

Communications for the Editor and Books for Review should be addressed, Editor, "KNOWLEDGE" Office, 326, High Holborn, W.C.